DOCUMENT RESUME

ED 112 943 95 IR 002 657

AUTHOR Mitzel, Harold E., Ed.
TITLE An Examination of the Short-Range Potential of Computer-Managed Instruction. Conference Proceedings (Chicago, Illinois, November 6-8, 1974).
INSTITUTION Pennsylvania State Univ., University Park. Coll. of Education.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE 75
CONTRACT NIE-C-74-0091
NOTE 86p.

EDRS PRICE MF-$0.76 HC-$4.43 Plus Postage
DESCRIPTORS Achievement Rating; *Computer Assisted Instruction; Computers; *Conference Reports; Educational Research; Educational Technology; Higher Education; Individualized Instruction; Industrial Training; *Instructional Technology; Military Training; Professional Training; Teaching Methods
IDENTIFIERS Air Force Advanced Instructional System; Classroom Teacher Support System; Computer Managed Geometry; *Computer Managed Instruction; HumRRO CMI; Navy CMI Systems; Ohio State University College of Medicine CAI; Program for Learning in Accordance with Needs; Project ABACUS; Project PLAN; Stony Brook CAI Laboratory

ABSTRACT

Adaptation of computers to instructional use in academic settings, the military, and industrial training provided the focus for this conference on computer managed instruction (CMI). Part 1 of the proceedings contains an orientation to computer managed instruction; Part 2 consists of brief descriptions of 23 CMI systems; and Part 3 is a summary of the conference evaluation. An article on the future role of the computer in basic education is appended. (CH)

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CONFERENCE PROCEEDINGS

AN EXAMINATION OF THE SHORT-RANGE POTENTIAL OF COMPUTER-MANAGED INSTRUCTION

November 6-8, 1974
Chicago, Illinois

Harold E. Mitzel, Editor
The Pennsylvania State University

Sponsored by
National Institute of Education
Grant No. NIE-C-74-0091

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INTRODUCTION

The idea for a small invitational conference on the potential value to the education enterprise of Computer-Managed Instruction had its origin in two unrelated developments.

First, the last ten years have seen an increasing interest in futurology, an attempt to forecast our society's problems, practices, customs and shortcomings by the end of the century (Toffler, 1970, 1974; Bell, 1973; Burdin *et al.*, 1974). Second, educators interested in technological applications in schools are painfully aware that the rapid adoption of computers for instructional use has not lived up to our expectations of the 1960-65 period. Because research and development on computer-based education is so decentralized, it seemed like an appropriate time to assess the current state of the art by assembling a small number of men and women who were actually in the process of developing and refining systems of instruction involving computers in significant roles. We recognized that there were three main divisions of the contemporary R & D effort and the Planning Committee was organized around academic applications (including both college and lower school levels), military applications, and industrial training uses.

In planning the Conference invitation list, we deliberately sought out those people who had solid experience with one or more systematic attempts to develop and evaluate a computer-managed instruction system. One-hour presentations about functioning CMI systems were requested from nine of the invited participants. In choosing the nine different programs for Conference presentation, the Planning Committee attempted to achieve a balanced presentation between the three divisions–academic, military and industrial. Balance was also sought in trying to be sure that all major sections of the country were represented.

The following pages document the proceedings of the Conference and the report is divided into three parts. Part I contains the Conference Planning Abstract which was sent to all participants several weeks in advance of the meeting, held November 6-8, 1974 in Chicago, Illinois. In addition, a valuable paper by Dr. Robert G. Scanlon on present trends and future directions was included here because of its orientation to likely new developments. The Scanlon paper was first presented at a Special Superintendents' Seminar held at the IBM Center, San Jose, California, July 9, 1974. We are indebted to the International Business Machines Corporation and to Dr. Scanlon for giving us permission to reprint it here. This paper was distributed to Conference participants approximately one week in advance. The remainder of Part I consists of four short talks prepared by members of the Planning Committee and Dr. Michael W. Allen. These talks, given in the opening session of the Conference, were focused upon the special conditions and characteristics of the academic, military and industrial milieux which are relevant to the development of CMI systems.

Part II consists of brief descriptions of 23 CMI operating systems which were represented by participants at the Conference. Each participant was invited to bring and distribute two typewritten pages of information about a CMI system in operation at his/her home institution. These reports have been edited and are incorporated into the Proceedings. Because one of the major purposes of the Conference was to facilitate an exchange of up-to-date information among professional developers of CMI systems, your editor believes that this portion of the proceedings presents the record of the Conference's greatest value to the field.

Part III of these proceedings is a summary of the Conference evaluation. We asked five questions of the participants at the close of the Conference and requested responses on a five-point scale to each question. An additional opportunity was provided for participants to make a comment about any aspect of the Conference which impressed them either positively or negatively.

We are grateful to Mr. Arthur Melmed and Dr. Glenn Ingram of the National Institute of Education for encouraging our efforts and for guidance in planning the meeting. Our thanks to the International Business Machines Corporation for providing the Conference with an attractive meeting room at the Education Center in Chicago and for computer support for several of the demonstrations by participants. The Planning Committee, composed of Dr. John Bolvin, Dr. Henry T. Lippert and Dr. Harvey Long, was especially diligent in meeting the deadlines and peremptory demands of detailed program planning and execution. Mr. Wally Lester of Penn State's Conference staff provided invaluable service in coordinating the several sessions and in assisting participants. My graduate assistant, Ms. Melissa Berkowitz, handled a thousand details and ran dozens of errands. Her efforts are warmly appreciated. Finally, our gratitude to the busy men and women engaged in educational applications of computers who, without remuneration, took the time to come to Chicago and exchange information with their colleagues.

References

Bell, D. *The Coming of Post-Industrial Society: A Venture in Social Forecasting.* New York: Basic Books, 1973.

Burdin, J., Graham, R.A. & Rubin, L.J. (Ed.) Thematic section on futurism in education. *Journal of Teacher Education,* 1974, **25**(2), 98-153.

Rubin, L. (Ed.) *The Future of Education: Perspectives on Tomorrow's Schooling.* Boston: Allyn & Bacon, 1975.

Toffler, A. *Future Shock.* New York: Random House, 1970.

Toffler, A. (Ed.) *Learning for Tomorrow: The Role of the Future in Education.* New York: Random House, 1974.

PART I

ORIENTATION TO CMI

CMI Conference Planning Abstract
Executive House, Chicago, Illinois
November 6-8, 1974

AN EXAMINATION OF THE SHORT-RANGE POTENTIAL OF COMPUTER-MANAGED INSTRUCTION

Harold E. Mitzel
The Pennsylvania State University

Introduction

It is evident that computers have not lived up to the educational potential that was envisioned for them about a decade ago (Baker, 1971; Carnegie Commission, 1972; Tickton, 1970, p. 74). This conclusion applies particularly to tutorial uses of computer hardware and to specially constructed computer-based course materials. Some possible explanations for the delay in the application of computer technology include the following overly simplified notions: 1) too much capital required for massive equipment acquisition, 2) lack of adaptability of business-oriented hardware to instructional functions, 3) an overly decentralized education market, 4) the lack of resources for developing even minimal amounts of computer-based course material, 5) a skeptical, anti-technology attitude on the part of teachers and other educators, etc. For whatever the reasons, computer-assisted instruction (CAI) involving an integral (not supplementary) and interactive use of computers is developing much more slowly than was envisioned in the early 1960's.

A somewhat less intensive use of computers than in CAI takes place in computer-managed instruction (CMI). By means of a small invitational conference, an examination of the near-term potential of computer-managed instruction will be conducted. Our thesis is that in the rush to get large numbers of students into an interactive mode on computer terminals, some of the basic potential of computer-managed instruction for contributing to the achievement of instructional goals in schools, colleges, industries, postsecondary schools and military training centers may have been overlooked. Our suspicion that educational technologists "missed the boat" by first going for the exciting and exotic CAI applications is not advanced in the spirit of blame or in the glorification of hindsight, but in the sense of "taking stock" of the present situation.

It is unlikely that any direct documentary evidence exists that can answer the question of where to put the developmental emphasis for computer applications in education during the next five years. An approximate answer, however, could come from the process of several good men and women reasoning together by pooling their knowledge and experience.

Ideally, we should be able precisely to define the term computer-managed instruction, even though for some humanists it conjures up images of people being manipulated by machines. *We take the position that CMI is information processing,* but that the information being processed is one step removed from direct instruction. CMI offers a kind of middle ground of computer application on a continuum between CAI (tutorial) and administrative data processing.

It has been three years since Baker's review of computer-based instruction management appeared in the *Review of Educational Research* (Baker, 1971). Most of the problems and inadequacies which he identified are still with us. There have been, however, a number of additional systems developed and there seems to be a resurging interest in CMI applications. We are seeing the appearance of new terminals, both plasma and cathode-ray tube, which should increase the output speed of computers involved with CMI applications. These events argue for a careful re-examination of the early potential of computer-managed instruction.

Computer-Managed Instruction

The state-of-the-art in computer-managed instruction suggests that there are currently three levels of application. In Level I the computer is used with instructor-input in *batch processing mode* to tabulate and accumulate systematic information about marks, attendance, test performance, etc. At this rudimentary support level, the role of the computer is chiefly one of replacing high quality clerical and tabulation services. In Level II the computer is still used with instructor-input in *batch processing mode* to accumulate records of student performance, and *to feedback* these cumulative records to both the instructor and the student on a scheduled basis. A periodic prescriptive function, however, has been introduced at Level II advising students on a differential basis of what they need to do to remove various deficiencies which have arisen from their instructor's evaluation of their performance on the modules. Examples of Level II CMI include the Automated Instructional Management System developed at New York Institute of Technology and the Instruction Support System now in use on a pilot basis in the College of Education at Penn State University.

Level III of computer-managed instruction systems is characterized by a *real time interactive* interface between the learner and the computer, and by a diagnostic-prescriptive logic keyed to the student's responses to the material stored in the computer. Relatively few examples of these sophisticated CMI systems are now operable.

Purpose

A three-day invitational conference/workshop under the sponsorship of the National Institute of Education on the general theme of Computer-Managed Instruction will be held. The conference/workshop will be held at the Executive House, Chicago, Illinois during November 6-8, 1974. About 35 experienced researchers and developers from schools, higher education, industry, government and military training will attend. In order to give the conference balance and to keep it from being all "telling," several experts from among the participants have been invited to "show" and/or demonstrate the highlights of a currently operating CMI system. It is a workshop in the sense that the majority of the participants are themselves actively working with one or more CMI systems. Each person should expect to learn something useful from the experience which he can take home and apply. To facilitate the demonstration and the workshop component, access will be provided to the participants on a large computer facility in downtown Chicago.

The following list of 10 questions illustrates those to which the conferees will be expected to address themselves during the meeting:

1. What are the current impediments and constraints to widespread application of CMI in education and training?

2. Given the current amount of underutilization of installed computing power in education institutions, what proportion of these institutions could use a CMI application without a new central processor acquisition?

3. What modification to typical existing operating systems would need to be made to accommodate CMI, and how much would these modifications cost?

4. Assuming that an institution or a training facility interested in CMI now has no significant computer hardware investment, what are the strengths and weaknesses of several minicomputers versus one large central processor?

5. Assuming there are about three distinct levels of complexity of CMI systems, which level, at current computer costs, offers the best instructional value? What level of complexity will likely offer the best instructional value in a decade from now?

6. Which of our society's social values are likely to be enhanced by widespread application of CMI? Which prevailing values will be challenged or threatened by CMI?

7. How does a CMI innovator go about shifting a faculty, administration, and student body from mass education methods to individualized adaptive education where the computer is the focal point instead of the teacher?

8. By what method and at what rate does an instructional developer introduce CMI into an educational institution—gradually or all at once?

9. What are the likely new hardware and software developments in computer technology during the next decade that would significantly impact CMI either adversely or positively?

10. Is there a mandated developmental sequence and time-line for technological adoptions in the U.S. (sometimes estimated at 30 years), or is it possible to make short-cuts in the developmental process?

Steering Committee

A Steering Committee composed of the following persons has met and planned the program. The committee will be responsible for editing a comprehensive final report.

Chairman

Dr. Harold E. Mitzel
The Pennsylvania State University
University Park, Pennsylvania

Academic Representative

Dr. John Bolvin
University of Pittsburgh
Pittsburgh, Pennsylvania

Industry Representative

Dr. Harvey Long
IBM Corporation
Bethesda, Maryland

Military Representative

Dr. Henry Lippert
Academy of Health Sciences
U.S. Army
Ft. Sam Houston, Texas

Attendance

Attendance at the conference is by invitation only. Transportation and per diem expenses including lodging will be reimbursed for participants. Usually only one representative of an installation can be accommodated.

References

Baker, F.B. Computer-based instructional management systems: A first look. *Review of Educational Research,* 1971, **41**, 51-70.

Carnegie Commission on Higher Education. *The more effective use of resources.* New York: McGraw-Hill, 1972a.

Carnegie Commission on Higher Education. *The fourth revolution.* New York: McGraw-Hill, 1972b.

Cooley, W. & Glaser, R. An information and management system for individually prescribed instruction. In R.L. Atkinson & H.A. Wilson (Eds.) *Computer-Assisted Instruction.* New York: Academic Press, 1969.

Finch, J.M. An overview of computer-managed instruction. *Educational Technology,* 1972, 46-47.

Flanagan, J.C. Project PLAN: Basic assumptions, implementation, and significance. *Journal of Secondary Education,* 1971a, **46**, 172-178.

Flanagan, J.C. The PLAN system for individualizing education. *Special Report of the National Council on Measurement in Education,* 1971b, **2**, 1-8, ED 051 296.

Geddes, C.L. & Kooi, B.Y. An instructional management system for classroom teachers. *Elementary School Journal,* **69**, 337-345.

Healy, J. COMPUTRAC: Monitoring student classroom performance. *AEDS Journal,* 1971, **4**, 69-74.

Johnson, K.A. *Computer-managed instruction.* Naval Air Station, Memphis, Tennessee, 1973, 33p. mimeographed.

Kelley, A.C. An experiment with TIPS: A computer-aided instructional system for undergraduate education. *American Economic Review,* 1968a, **58**, 446-457.

Levien, R.E. (Ed.) *Computers in instruction.* Rand Corporation, R-718, July, 1971.

Lippey, G., et al. Computer-based exercises aid classroom teachers. *AEDS Journal,* 1971, **4**, 75-84.

Mitzel, H.E. Computers and adaptive education. *American Education,* 1970, **6**, 23-26.

Mitzel, H.E. Computer technology: Its future role in basic education. *Journal of Teacher Education,* XXV, Summer, 1974, 124-129.

O'Dierno, E.A. *A progress report on the development of a generalized educational management system.* Advanced Systems Laboratory, New York Institute of Technology, 1969.

Schure, A. An accountability and evaluation design for occupational education. *Educational Technology,* March, 1971, 26-37.

Silberman, H.C. *Design objectives of the instructional management system.* SP 3038/001/00, Systems Development Corporation, Santa Monica, California, 1968.

Sorenson, P. Program for learning in accordance with needs. *Phi Delta Kappan,* 1970, **52**, 180-181.

Steffenson, R.G. & Read, E.A. A computer program for management of student performance information. *Audio-Visual Instruction,* 1970, **15**, 56-59.

Tickton, S.G. (Ed.) *To improve learning: An evaluation of instructional technology.* Vol. 1, New York: R.R. Bowker, 1970.

Wright, C.E. Project PLAN progress report. *Education,* 1970, **90**, 261-269.

Abstract of a Paper Presented at Special Superintendents' Seminar
IBM Education Center, San Jose, California
July 9, 1974
(Reprinted by permission)

COMPUTER-MANAGED INSTRUCTION: PRESENT TRENDS AND FUTURE DIRECTIONS

Robert G. Scanlon
Research for Better Schools, Inc.

Introduction

In the mid 1950's, while still in its infancy, computer technology entered the world of education. First used primarily as a research and administrative tool on college and university campuses, computers soon set off the imaginations of innovative educators who foresaw the possibilities of using computers as instructional tools. They developed and applied computer technology to educational problems and worked toward a revolution which would win for education its ultimate goal–individualized instruction. Clearly, the obvious benefits of the computer in individualizing instruction would stimulate rapid and radical changes in education, and early predictions saw the imminent automation of schools.

But, while a wide range of computer applications to education can be listed and dozens of demonstration projects can be cited, the promises put forth by early proponents of computerized education remain largely unfulfilled in the 1970's. The instructional use of computers has continued to lag far behind their use for administrative and research purposes. Most of the sophisticated instructional systems have not yet advanced beyond the experimental stage. Those actually implemented have not been widely used.

This relatively limited instructional use of computers has led to very different and even contradictory predictions about the future of computers in education. On the one hand, some proponents still foresee an imminent breakthrough in the use of computers in education. On the other hand, the critics feel the computer revolution in instruction is still far off in the future, if ever.

Present Trends in CMI

My survey of the present status of computer-based instructional management systems is limited to applications in elementary and secondary schools. It will not, therefore, reflect the current activity in higher education, military institutions and in industry; albeit that successful, economically viable applications of CMI in other areas are likely to have positive effects upon *future* applications in the schools and for that reason warrant careful watching.

This status report is based on information available in the literature and from conversations with a number of people involved in CMI projects. Obviously, we have not identified all the operational programs. Documentation of operational CMI programs is very sparse and some information is simply not available.

Local district experimentation with CMI seems to be growing, but these programs are, of course, the most difficult to identify. There is the added problem of determining just what is included under the CMI umbrella. A few agencies which claim (in their promotional literature) to have CMI candidly admit that what they actually have is a component of a potential CMI system.

We have organized the various activities in CMI into three separate categories: Major Instructional Systems, Local School Systems, and Related Activities.

Major Instructional Systems. Frank B. Baker wrote a state-of-the-art review on the major Computer-Based Instructional Management Systems about five years ago. The systems he described are still the major systems in existence. Figure 1 provides recent information on five systems designed for use in elementary and secondary schools.

IMS. Although a number of systems were conceived at about the same time–the late 1960's–the first to become operational was the Instructional Management System developed by Systems Development Corporation for the Southwest Regional Labs. The program was run for 2½ years in a number of schools in Los Angeles using curriculum in mathematics and reading. However, the system is said to be adaptable to any curriculum which has clear, concrete learning objectives. The system provides for frequent testing profiling, individual study recommendations, and summary reports on all tests. It is purported to help make decisions regarding pacing, grouping, sequencing

PROJECT	DEVELOPER	STATUS	NUMBER OF STUDENTS INCLUDED	TYPE OF STUDENTS	CURRICULUM	COST/ EFFEC-TIVENESS
Instructional Management System (IMS)	System Development Corporation ——— Southwest Regional Lab	Developmental	200 Classes , 6,000 Students	Any	Reading-Math Drama-Public Speaking Art-Music	No Data
Program for Learning in Accordance with Needs (Project PLAN)	Westinghouse Learning Corporation *and* American Institutes for Research	Operational	45,000	Grades K-12	Uses Existing Materials in Language Arts Science-Math Social Studies	No Data
Individually Guided Instruction (IGE)	Wisconsin Research and Development Center for Cognitive Learning	Developmental	8-30 Schools	Elementary	No Data	No Data
Individually Prescribed Instruction (IPI)	Learning Research and Development Center at University of Pittsburgh	Experimental	1 School	Elementary	Math	No Data
Automated Instructional Management Systems (AIMS)	New York Institute of Technology	Operational	1 School District	Any	Math	No Data

Figure 1. MAJOR CMI SYSTEMS

and individualization within a conventional classroom setting.

PLAN. Project PLAN is a major ungraded, computer-managed individualized learning program developed by the American Institutes for Research and now marketed and monitored by the Westinghouse Learning Corporation. The components of PLAN include behavioral objectives, teaching-learning units (TLU's), testing procedures involving use of criterion-referenced tests related to the objectives within the units and to the long-term educational goals, guidance and individual planning and teacher development. A central computer in Iowa City, Iowa, is used to store and analyze the information and to send reports back to the schools on a daily basis. The system utilizes existing instructional materials. Presently, PLAN is said to involve 45,000 students in grades K-12. Cities where schools have been using PLAN include: San Jose and San Francisco, California; Pittsburgh, Pennsylvania; East Orange and Ridgewood, New Jersey.

A recent EPIE evaluation of PLAN reported that although initial costs are very high, a school system that had been in PLAN over a period of several years could figure on about $42 per pupil for all contractual services (for the school year 1973-74).

IGE. Individually Guided Education is a comprehensive system of instruction at the elementary school level. The major components are: a model for instructional programming for the individual student, a model for developing measurement tools and evaluation procedures, and an organizational-administrative component called the multi-unit school.

The IGE programming model makes use of behavioral objectives and criterion-referenced tests. Presently, CMI is not a part of the IGE system which is now operating in more than 1,000 schools. However, CMI is being introduced on a trial basis in 8 schools with plans to expand the trial to 30 schools in the near future. The computer-based system will provide test scoring, achievement profiling, diagnosis, prescription, and instruction.

IPI/MIS. The IPI Management and Information System makes use of detailed objectives, methods and materials to obtain the objectives, determination of individual competence, continuous evaluation and student performance monitoring. The computer is being used on an experimental basis in the Oakleaf School to collect and process information on each student and to supply summary reports to teachers. This system is specifically designed for use with the IPI curricular materials.

AIMS. The Automated Instructional Management System developed by the New York Institute of Technology is reported to be in use in at least one school system (Mineola Public Schools, Mineola, New York). The system is specifically designed to be independent of the course or curriculum, subject area or level, so that, according to its developers, it can be utilized with any course materials designed around behavioral objectives. The system utilizes teletype terminals for immediate reports on progress to students, while reports to instructors and curriculum designers are batch processed. AIMS includes information on objectives, students, curriculum and facilities, instructional strategies, tests and feedback. Its functions include evaluation of student progress, prescriptions, and empirical validation and optimization of instruction.

Local School District Activity. There are indications that local districts, in some cases, with technical assistance of a research group and financial support from federal funds, are developing CMI systems to meet their own needs and specifications. One example of a locally developed system has been developed by Katherine Morgan of Montgomery County, Maryland.

An example of a local CMI program is the Instructional Management Program (IMP) in the Philadelphia Public Schools. This program is designed to ensure that each student achieves minimum standards of performance in basic skill areas. The program was developed in one school and has spread to six other schools in the district, involving more than 2,500 students. Each school sets its own standards of performance on basic objectives.

Learning takes place through independent study packets, student tutoring, and professional tutoring. Each step in the learning process is prescribed by a computer system which matches the available learning options to the individual needs and characteristics of the student. The unique features of this program are its concentration on basic objectives and the attempt to match student learning styles to the teaching characteristics of curricular materials.

Other CMI programs are in operation in Philadelphia, and in Madison, Wisconsin; Cedar Rapids, Iowa; and other school districts.

Related Activity. There are a few computer-based testing programs which have some instructional management features. Three programs of this type are: Comprehensive Achievement Monitoring (CAM), Student Achievement Monitoring (SAM), and the Classroom Teacher Support System (CTSS).

CAM is a computer application to instruction which monitors individual student progress on specific behavioral objectives. It is essentially a computer-based testing system which includes pre-tests, mini-exams, and follow-up data on student retention. The data can also be manipulated by the computer to produce program evaluation data. CAM is being used in a number of schools in the country and the concept is also incorporated in the Minnesota/Ties system and in a program called PREP under development at the General Learning Corporation. Operational programs are reported in schools in Arizona, New Jersey, New York, Illinois and Minnesota. SAM, which is very similar to the CAM concept, has been in operation in the Oakland School District in Michigan for a number of years.

The Classroom Teacher Support System (CTSS) developed by IBM provides clerical and logistical support for the teacher who continues to make the decisions. The teacher specifies the objectives and the test function is accomplished by the program. It is in use in the Los Angeles City Unified School District.

Still another computer-supported system for tracking and guiding student progress is Tracer. Tracer is commercially available from Educators Alliance in Palo Alto. I believe that Hewlett-Packard is developing a CMI system as well.

Conclusions. This brief review of the present status of CMI in schools suggests the following conclusions.

1. *There seems to be considerable interest in CMI at the local school level.* A number of small CMI systems are operational or under development in individual schools or school districts. This seems to be a direct result of the management problems which are encountered as schools individualize their educational programs.

2. *CMI systems are still under development in many large-scale instructional programs.* Despite early predictions, IGE and IPI have not yet introduced operational CMI systems. The developers have tended to concentrate on the continuing redesign and redevelopment of the instructional program itself rather than building a computer management system. This situation should change in the immediate future.

3. *Virtually no data exists on the cost-effectiveness of CMI.* While I suspect CMI may be a cost-effective technique, I can only support my opinion with some preliminary analysis of IPI done at RBS. We estimate that most of the cost of adding a computer management system would be offset by reductions in the number of aides required to do the clerical work. Further, we feel we can add some features to the program which might make it more effective. I simply don't know of any literature which might support or refute my feelings in this matter.

Future Directions

In one of our projects at RBS, we are attempting to forecast future developments in education and design educational programs which are based on these developments. One of our major interests is the role computer technology might play in schools in the immediate future.

As a point of departure, we have been conducting conferences on educational futures and educational technology. Not surprisingly, we are finding that educational futurists have different visions of the role of the computer in education over the next few years. Figure 2 indicates the reasons some people have offered for or against a dramatic increase in computer use in the near future. The people predicting a strong increase point to recent developments in computer technology, including the steadily decreasing cost of computing and the continuing increase in the availability of curricula and software materials. More importantly, they view trends in education toward more accountability, higher levels of individualization, and improved productivity as leading to more computer usage.

Others predict a limited role for the computer, at least in the immediate future. These people cite major problems with the application of computers to education such as the potential for depersonalization of the educational process, the limited financial resources available for technology, the resistance to computers from traditional teachers and teachers' unions, and the lack of cost/effectiveness data on instructional uses.

Dramatic Increase	Limited Role
Decreasing Cost of Computing	Potential for Depersonalization
Increasing Availability of Software	Limited Financial Resources for Technology
Emphasis on Accountability	Resistance from Traditional Teachers and Unions
Movement Toward Individualization	Lack of Data on Cost/Effectiveness in Instruction
Need for More Productivity	

Figure 2. PREDICTIONS ABOUT INCREASED COMPUTER USE IN SCHOOLS

We are presently analyzing this mass of prediction and contradiction to isolate some common themes which will provide a strong foundation for designing school programs. In the remaining time, I would like to outline our thinking on designs for schools of the future emphasizing the role of computer-managed instruction in these designs.

Our fundamental assumption about the future of American education is that schools in 1980 will be at least as diversified as they are now. It is highly unlikely that all schools will ever adopt a single set of educational goals, methods, or materials. On the contrary, we expect the present movement toward decentralization, local autonomy, and alternative schools to result in even more diversified educational programs in schools of the future.

However, we also believe that many schools in 1980 will share some objectives in common. For example, we believe the propositions listed in Figure 3 reflect some of the major needs and problems of schools in the near future.

The Emerging Confrontation. Decreasing school enrollments and increasing educational costs will result in a confrontation between educators and taxpayers.

Educational Productivity. Educational costs and instructional effectiveness will become primary considerations.

Basic Education. There will be increased emphasis on the development of certain basic skills.

Mastery Learning. A determined effort will be made to ensure that every student masters the basic objectives of education.

Quality Education and Desegregation. Integration of the schools will be directly related to improving the quality of education for all students.

Individualization and Personalization. Individualization and personalization of the educational process will become accepted practice at least in certain curricula areas.

Figure 3. PROPOSITIONS ABOUT SCHOOLS IN 1980

The Emerging Confrontation. Decreasing school enrollments and increasing educational costs will result in a confrontation between educators and taxpayers. Educators will view decreasing enrollments as an opportunity to improve the quality of education mainly by reducing class size. Taxpayers will see decreasing enrollments as an opportunity to reduce costs primarily by cutting staff positions.

Educational Productivity. Educational costs and instructional effectiveness will be primary considerations in all educational programs. Technology, including both hardware and software systems, will be widely used to reduce costs while maintaining or even enhancing effectiveness. Schools will be held accountable by the public for teaching in an efficient and effective manner.

Basic Education. There will be increased emphasis on the development of certain basic skills in all educational programs. A broader definition of the basics will be accepted by most schools to include not only the traditional cognitive skills in reading, writing and arithmetic, but also some affective and career concepts. Educators will place more emphasis on affective concepts such as teaching conflict resolution and moral judgments, as well as career concepts involving exploring careers and specialized experience in selected career choices.

Mastery Learning. A determined effort will be made to ensure that *every* student masters the basic objectives of education. Educators will recognize that every student can learn the basics when provided with a program that truly adjusts to individual differences in learning.

Quality Education and Desegregation. Integration of the schools will be directly related to improving the quality of education for all students. Solutions to the desegregation problem will take the form of providing better education for students rather than busing to force integration.

Individualization and Personalization. Individualization and personalization of the educational process will become accepted practice at least in certain areas of the curriculum. Basic skill education and integrated learning situations will be major targets for individualized learning programs.

General Conclusions

Three general conclusions can be reached on the basis of this review of present trends and future directions in CMI.

1. Widespread use of CMI will occur if schools individualize instruction using structured curricula materials. Developing a computer management system is a fairly simple task if the curricula materials in use have well-defined behavioral objectives, alternative teaching methods, and criterion-referenced tests. Materials of this type are still not widely used in schools. A major obstacle to the use of CMI is the lack of published curricula materials which are highly structured.

2. CMI has suffered from the lack of a nationally prominent demonstration project. PLATO and TICCIT have provided a vehicle for experimenting with CAI and demonstrating its potential to the educational community. On the other hand, the potential of CMI has not been systematically explored in a large-scale, federally-funded project. Consequently, the use of the computer as a management tool has not been brought to the attention of educators or the public at large.

3. Finally, I would like to conclude with a word to our hosts. Educational technology is best defined as the application of scientific processes and products to the improvement of education. At its worst, it is considered labor-saving hardware and electronic gadgetry. We would all do well to remember that it is up to the makers of machines to carry out the tasks we present; it is not up to us to warp our systems in order to provide work for a machine designed to do something else.

Most of the curricula and materials for these programs are already available. A system for focusing, integrating, and managing the programs is not available. In fact, the operation of these programs without a computer management system is almost inconceivable.

Computer management becomes mandatory when a program involves large numbers of students, many different grade levels, highly individualized materials, a number of subject areas, and diverse learning environments. Tracking, scheduling, and evaluating students under these conditions requires computer assistance.

For example, in the programs outlined above, data would be collected at periodic intervals on individual student objectives, aptitudes, and interests. The computer would use these data to track student progress at each step in the learning process, to schedule student learning activities on the basis of individual needs, to supply clerical assistance and management data to teachers, and to provide evaluative information to administrators on the effectiveness of instruction.

The particular examples used here are only two designs for schools of the future. We have models for a number of other programs. The critical point is that in every single design we find a vital need for a computer-managed instructional system. We believe CMI will play a critical role in schools of the future.

COMPUTER-MANAGED INSTRUCTION: THE ACADEMIC SCENE

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As I'm sure will be stated by others, the application of computers to education has failed to live up to their predicted potential in our elementary and secondary schools, and in undergraduate colleges. Of course, there are many reasons for this, most of which we are all familiar with just by the nature of our positions. However, it is the belief of some, and I wish I could say many, that the greatest potential for computer use in the near future seems to be in the area of assistance to the management aspects of the learning process. Directly related to this belief is the more general concern for individualized, personalized, or adaptive education. Therefore, in order to examine the potential uses of the computer we should back up and look at the instructional needs of the students and the effects these needs have on the institution. To examine the instructional needs of a given student at a given time, there are many variables or factors that should be considered. Where is he now? Where does he want to go? What goals does society say he should have in addition to his own goals? What does it take to help him reach both his own goals and society's goals? What is the most effective means of helping him obtain these goals? All of these questions imply that instruction begins with the individual student and not with groups. They imply that education plans should begin with individual's both long and short term designs. They imply that the resources to be utilized in the instruction program should be geared to individual styles, rates, needs, previous experiences, and interests of the learner. In short, effective instruction means adaptability to the student.

Individualization of Instruction

To date, nearly all of the programs for elementary and secondary schools and for undergraduate colleges that have attempted to provide for individualization have begun by examining the instructional needs for a single subject, and then sometimes combining these single subjects into a single system. Individually Prescribed Instruction has primarily been concerned with reading, mathematics, science, and spelling. Project PLAN (see Table 1) has emphasized reading, mathematics, social studies, language and science, to mention a few at the elementary and secondary levels. At the undergraduate level the subject areas where attempts to adapt have been more widespread include: mathematics, English or English language, science courses and psychology—again single courses. Although this approach is not necessarily a poor one, it does provide limitations for management needs that directly relate to computer assistance in management. A single subject approach generates information needs of a particular kind that relate to the individual student differences and are of concern for instruction. The broad categories of individual differences that now seem to be of concern include providing for:

1. differences in entering level of achievement among students in a given class,
2. differences in rate of learning toward certain fixed goals for the course,
3. differences in gross learning styles by having available a limited variety of resources and materials,
4. those individual differences among students that relate to student-teacher interaction needs,
5. certain select subject goals for some students and not for all, and
6. a limited degree of attention to individual differences relating to differences in attitude and motivation of the learner toward learning and instructional tasks.

It should be pointed out here that in addition to the general goal of adaptive or individualized instruction that is serving as a basis of need for computer-assisted management, there are several other goals. One of these is the goal of mastery or proficiency of the subject matter. Another is developing self-directed and self-initiated learners. And still another goal is to develop learners who can begin to evaluate their own needs, progress, and outcomes. These last several goals relate to more concern by educators for the active role of the student in the learning process.

All of these factors then relate specifically to the general environmental needs of instruction in the elementary, secondary and undergraduate programs at this time. These needs can best be described in terms of the instructional elements that are of major concern to practitioners:

Goals and objectives
Pupil diagnoses

Instructional resources
Instructional strategies
Classroom management
Pupil outcomes
Program evaluation

Let me just say a few words about each of these components and point out briefly what kinds of information we now provide the practitioner, what the weaknesses are with this information, what we might provide them, and in some cases, how information might be provided.

Goals and Objectives

At the present time we more often than not provide in some document to teachers and others the overriding goals of the institution and its program. These goals are usually stated once, verbalized by all, and then set aside hoping that the instruction system is designed to reach these broader goals. If general goals come up again, for the teacher or institution, it is usually at the time of evaluation. On the other hand, particular course objectives are usually well developed, quite comprehensive, are compiled in several documents and repeated either as individual objectives or groups of objectives on materials, tests, forms, etc. By the emphasis placed on the documentation of these objectives there is no doubt that they are important. In addition to providing the statement of objectives, we organize them into units, clusters, levels and topics. This organization helps both students and instructors and is a real strength to instructional programming. A weakness that should be pointed out, however, is that because they get the emphasis they do, often these objectives become ends and not means as intended. To adjust for means-end confusion we need to begin establishing priorities of objectives relative to total outcomes. These priorities need to be explicit and well documented for classroom use. Through the priorities we need to call attention to alternative sequencing, objectives that serve as prerequisites to others and for what reason. I think what many of us have observed over time is that some of the original supporters of the concept of individualized and more systemized instructional programs have backed away because of the seeming rigidity that has come into the programs because we have not paid attention to inequality among the objectives. Some objectives are more important than others, especially as we think about individual students.

Student Diagnosis

At the present time instructors are provided information of both general and specific nature. Also, they are usually provided some prerequisite information as well as the pre-instructional kind, and most of this is criterion-referenced rather than norm-referenced. The weaknesses here from the practitioner point of view, however, are that there is too much concern for the specific objective learning outcome and not enough concern for the means by which the student can obtain the knowledge. How long might it take a student to "master" a particular objective? Is it worth it at this time? What strategies should be employed? Watch teachers...the first thing they want to eliminate now in many programs is the pre-instructional tests because the student time taken doesn't seem to have an information payoff. Also, at the same time teachers tend to keep the post-instructional tests and even impose rigid standards. What should be the standards for whom, when, and why? These must become part of the diagnostic and student assessment programs. Here the computer can play a real role since it can store large quantities of data over time for many students.

Instructional Resources

Presently, we provide information as to what is available and often where, and how that should be used. Some programs spend hours categorizing new resources and materials and usually the updates are an addition to what is already there. Good! However, what is now missing—information on what does what better, for whom, and why? What is needed is information readily accessible to the practitioner (both student and instructor) that can assist in short-term student planning in a way that reduces the time for this planning. Part of this information should be an updated analysis of how the student is doing with the resources he is using. There is a real caution that must be stated here—that is a caution against the crutch. Do we have the student take the easiest route and create a crutch that he can't live without?

Classroom Management Planning

A real time-consuming aspect of any instruction program is classroom management planning. Presently, most systems provide information about what each student is doing and this information often implies

where the effort takes place. What is missing now, however, is system information and suggested procedures for using the information that can project student needs, relate these to resources and suggest alternative ways of matching the two. Again, the computer can assist in this aspect if we take the time to ask the proper questions.

Pupil Outcomes

And finally, just a word about pupil outcomes. In contemporary CMI systems, information does seem to be available as to how well each student has accomplished both individual and group objectives. However, little information is presently available about proficiency levels needed by whom and when. As stated earlier, this lack of analysis leads too often to certain rigid standards that may or may not have validity.

General Concerns About CMI Systems

Let me move on now and explore some general concerns that should be expressed about the present strengths and weaknesses of the information provided by CMI systems. Keep in mind that the total instructional management system is one that helps us relate all the pieces to the total or the whole. Presently we can provide information both to the instructor and to students as to what is going to be learned, what can be used to learn it, the student's readiness to learn it, and then whether or not the student accomplished the task satisfactorily. Also, we are able to have individual schools or individual instructors identify the objectives that seem important and necessarily to be considered in the system for a given course at a given time. This is all to the good. It can help us move toward adaptive instruction. However, this information base has built-in weaknesses that by their nature may destroy just what we are attempting to achieve. Since most CMI models are developed to be applied to the present *goal model* where the clearest goals are course or program goals and not the total educational goals, we may be building for defeat. This outcome may occur because as practitioners use the system, those goals that are clearly stated and included in the CMI system will become THE goals. Other goals, though intended, will be lost. Also, with a few exceptions such as beginning reading or beginning mathematics, there are probably very few course objectives that must be mastered at a particular time by any great numbers. Keep in mind that, in any given course or program, there are usually process objectives that are not only important to the particular course, but are important generally in learning. These are not presently included in most CMI systems since they relate to both content and procedures for learning the content, for example, "example–rule or rule–example." Many of our severe critics in elementary and secondary education in particular will be attacking us on the institutional and more general goals with probably good cause. What can be done about the present concerns? – 1) hopefully recognize them now, 2) next, for all levels we can pay particular attention to some of the weaknesses outlined above under each component, and 3) examine more carefully how technology is changing the outcomes as well as the means to the outcomes. In many instances we have stated desired outcomes before adding certain technological devices and systems, but these were merely stated and probably attained by only a few students. But what is the overall effect when more students are able to attain these goals? What is the effect of superimposing these goals upon the goals of other programs or other courses? Who is not screened out of what because they have or have not attained these goals? Directly related to this question is the question of who will select themselves out because they don't want to attain the goals.

What I am trying to point out here is that in most instances the application of CMI, like the application of other technological devices, changes the student outcomes or the product and not merely the means to the end.

Time-on-Task

Closely related to this concern is a concern for the present concept of "educational time" and its relation to CMI. Presently, our concept of time in the educational sense is generally speaking a constant–credit hours, carnegie units, math period, reading period, etc. We do vary these somewhat, but not a great deal. As we begin to adapt to individual needs, there is no real trouble with those who can accomplish the tasks in the same time that was allotted before or in faster time than was previously allotted. However, what about those students who need more time? Where does it come from and who decides? Granted, this is educationally a better problem to deal with than the problems that the present system creates, particularly at the upper elementary and high school level. However, to deal with this problem

honestly and effectively we will have to increase the instructional time for these students. This costs money and these additional costs will be blamed on the computer. We in this room have to begin to deal with the tensions created by programs that adapt to individual differences. We've got to describe some of these outcomes before they become problems. The time-on-task concept is going to be a major problem in colleges for, keep in mind, we charge by credit hour to a large degree and we assign workloads by the same concept. I'll not play this out any further, but I'm sure you see the problem. These problems are not necessarily the problems of industry or of the military. Also, they are not the major problem in some educational institutions today since we are still mainly concerned with single courses as the major element. But they are potential problems which could have a negative influence on development and acceptance if not dealt with now.

Summary

The variety of roles that the computer can play relative to instructional management has increased. But we need to look at the functions that it assists. The practitioner does need assistance in measuring, tracking, analyzing progress, etc. But the practitioner has other and sometimes more important needs that are overlooked. We need to work with and listen to the practitioner if we are going to build for what should be.

CONSIDERATION OF THE EFFECTS OF ACADEMIC ENVIRONMENTS ON CMI DESIGN AND FUNCTION

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It is apparent from the number of CMI-related presentations being made at the various educational conventions held throughout the world; the number of CMI programs being developed at universities, vocational schools, industrial training centers, government training centers, and even primary and secondary schools; and the assembly of this meeting which has brought together so many educators for whom CMI is a primary interest, that Computer-Managed Instruction is indeed a highly significant product of educational technology. The impact CMI will eventually have through making individualized education more universally feasible is probably not recognized even in the excited "in-group" discussions held daily among CMI system developers. But, in those discussions it is always observed that CMI has far greater potential for solving instructional problems and generally improving educational opportunities than is shown by the currently operational CMI systems.

Even though many of us see CMI as a much more promising educational tool, especially in the short run, tutorial CAI has seen the advantage of greater large-scale funding and has drawn the fascination of many for whom CMI might be a more practical and satisfactory solution. CMI developers, being extremely cost conscious, turned almost immediately from the development of programs in which the instructional subject matter was imbedded to generalized systems which need little or no revision to accommodate a variety of disciplines. In many cases, additional programming has been done to support insertion, modification, and deletion of course materials by non-programmer users; but few if any have had the funds necessary to develop a fully educator-oriented system having great flexibility for the non-student user. Programs to date, while frequently of the generalized type rather than the subject-specific type, are developed to solve local functional needs. Because most systems are programmed in higher level languages (e.g., FORTRAN), it is often said that systems can be modified to meet different needs rather easily. While this has been true in some cases, depending, of course, on the severity of the difference between the original functions the system was designed to provide and the new functions needed, systems have not been developed to provide a great deal of flexibility in support functions–flexibility which is required if the systems can be said to be adaptable to varied and changing attributes of the educational environment. Flexibility is required if a single system is to be appropriate for use in institutions other than the one in which it was originally developed.

The purpose of this paper is not to detail the various features which have been included in CMI systems, but rather to briefly enumerate some of the attributes of educational environments which need to be considered in either the design or adoption of a CMI system.

Faculty and Staff

Any instructional system which serves to augment humans in their capacity to stimulate and guide learning must give attention to the instructor/system interface. Just as it is important to provide individualized education opportunities for students, it is also important to allow instructors to specify the services CMI is to provide and the decision rules which the system is to follow. Systems which provide such individualized support for the educator can be said to have *variable management strategies.*

No single management strategy can ever be appropriate for all curricula, all instructional conditions, and all instructors, but perhaps the most important element of the academic environment to be considered is the individual differences among the instructional staff. There is no system which will not prove a failure if it is restrictive of the talents of the instructor or if it cannot be adapted to the instructor's needs. The following examples show how only slightly different requirements, if not met, can render any *fixed management strategy* system unacceptable for a given situation:

Professor C. L. Rodgers conducts a law course which has as an overall objective that students will learn to locate on their own authoritative sources of information. Throughout the course CMI is used to generate tests asking students for facts they must find in library materials. Professor Rodgers uses the system to randomly generate a unique test for each student. He also requires the system to repeat the same unmastered tests (omitting correctly answered questions) for each student until all the correct information is supplied. End-of-test feedback should be specific with respect to the information still needed, but non-directive–except on third and subsequent tests–with respect to where the information can be found.

Dr. S. J. Swenson supervises a large-enrollment physics course for college freshmen. A wide variety of multimedia instruction resources are available, but only in barely sufficient quantities. Dr. Swenson wishes CMI to generate a new random test each time her students request a test. End-of-test feedback should include not only a description of the material mastered and not mastered, but also a listing of the available resources which should be most helpful for each student's measured needs.

It is easily seen that Rodgers and Swenson would need to specify different test and feedback generation rules, although other system functions might be appropriately similar. Rodgers might be interested, however, in generating a test asking the student what resources he had attempted to use when little progress was indicated on subsequent tests, while Swenson might wish to have students choose one of several instructional media available on a given topic and have the system report to the student the relative effectiveness of his choices.

These examples could be elaborated further showing how some identical features of CMI could serve both equally well and how very different features might become necessary. The point is made, however, that any widely acceptable CMI system must have instructor-specified options in the management strategy. Options must include selection of testing procedures, scoring procedures, type of feedback, sequencing of course topics, provision of optional course modules, unrecorded practice tests, and many others.

Other faculty- and staff-related aspects to be considered are listed below:

1. *Availability.* In some cases, faculty cannot be readily available for student consultation. Systems that do not require a subject matter expert to be present at all times may be of value, while those which rely on the instructor to make frequent pedagogical decisions and to provide information to students on demand cannot be considered.

2. *Willingness to Adopt a New Role.* CMI tends not to support teacher-centered instructional practices and provide a new role for faculty as learning counselors. The breadth of variability in the management strategy of any system determines to a large degree the freedom of the instructional staff to teach the way they wish. CMI systems designed to support a narrow and specifically defined set of instructor behaviors will require new users to conform to this instructional style and may, therefore, find a very limited general utility.

3. *Commitment to Individualized Education.* Lack of a thorough understanding of contemporary educational philosophy and commitment to its principles may be a good indicator of faculty motivation to reform educational practices. Innovation is hard work, and the development of CMI curricula is no less difficult. An existing low level of motivation may well change once familiarity with the instructional goals and technology is gained. Nevertheless, recognition that faculty may wish to spend far less than the optimal effort in courseware development suggests that highly sophisticated systems may be less appropriate than very easily understood and operated ones, at least at the outset. Proposing a system which requires identification of learning hierarchies, specification of complex testing strategies, and a complete restructuring of instructional resources is simply unrealistic for many environments.

4. *Confidence in Subject Matter.* Variable time learning systems sometimes provide a challenge which faculty are unaccustomed to in that students may raise at any time insightful questions concerning advanced course topics or very basic questions usually dealt with only in the course introduction. When faculty or staff do not have a high degree of confidence in their knowledge of the subject matter, CMI's support of individualized pacing may become an unacceptable threat. CMI procedures can be used to provide reduced variance in subjects being taught concurrently, while faculty learn to deal with some of the new challenges innovation presents.

5. *Familiarity with Educational Technology (Computing).* Although many who support individualized education are more than capable of dealing with its challenges, many are also reluctant to bring the computer into the very human process of instruction. Fear of computer hardware or simple unfamiliarity in working with it may provide a significant problem for the CMI designer who must concern himself with man/machine interface. It is necessary for those who have little or no experience with computing systems—either

on-line or off-line—that their instructions be easily entered into the system without first having to translate them into an unnatural symbolic format. The extent to which these people perceive their ability to control the system may well determine its viability in the environment.

6. *Research Interest.* Some CMI systems are satisfactory to a particular group of users because the system provides an abundance of research data. Not all user groups are primarily nor even significantly concerned with such data, however, and systems which emphasize experimentation to the neglect of accommodating the different pedagogical requirements would be clearly unsuitable to them. Similarly, the lack of a data-collecting capability would make other systems unsuitable for those for whom ease of educational experimentation makes CMI appealing.

The character of the faculty and staff for whom various CMI systems were developed to serve can be easily determined by studying the specific attributes of any given system. But it can be clearly seen, even from the extremely brief listing and discussion above, that satisfaction of locally identified needs and the omission of concern for future needs as well as for those existent at other institutions will severely limit the universal utility and value of the system and most likely also limit the possible distribution of the courseware developed for it. Although faculty and staff demands and considerations may comprise the most significant class of environmental attributes affecting CMI system design and operational success, a number of additional attributes may also be identified as having effects which are by no means trivial.

Courseware and Equipment

Since CMI is an instructional support system, its success is closely tied with measures of learning which occurred under the system. But since CMI does not "teach," the quality of the instructional material it manages has a lot to do with the learning outcome and therefore CMI's evaluation. Only three of the many courseware and equipment factors which influence CMI are singled out below as examples:

1. *Existing Curriculum Structure.* The step from the traditional instruction format to fully individualized education managed by computer is a very large one indeed. The more objective-based and individualized the existing curriculum is, the less difficult CMI adoption will be. It is important to recognize, however, that CMI tends to be exasperatingly demanding with respect to the definition of objectives and the identification of learning resources related to them. Any undefined component behavior will not be tested and no study recommendation can be made when it is not mastered. Higher level behaviors building on such components may not be mastered because of the incremental learning deficit, and the system's being unable to determine the real cause will not suggest truly appropriate learning activities. No matter how sophisticated the CMI design, flaws in curriculum structure will be magnified by the system until restructuring is accomplished. Such flaws may ultimately bring discredit to the particular CMI system in use and erroneously indicate that less exacting methods of instructional management are superior. Judicious avoidance of such a frustrating situation may be accomplished by refraining from the introduction of CMI when the existing curriculum structure is inadequate and when a serious restructuring is not feasible.

2. *Individual Learning Resources.* Some CMI systems such as the one in operation in the Introductory Biology Project at The Ohio State University (Allen *et al.*, 1972) provide a practical means for the management of available instructional resources without the requirement of constructing special ones to meet the needs of the system's study prescription generator. At the heart of this design is the recognition that available resources may not relate to a single objective but rather to an identifiable group of objectives. Access to a relatively large library of such commonly available resources permits computer comparison of the set of measured student needs and the composite sets of needs served by the possible combinations of selected resources. An algorithm which can take into account previous prescriptions generated for the student, preferred instructional media, etc. is then used to recommend a study prescription.

Although individual learning resource management such as the one described can overcome some shortcomings in the resources themselves, the quality and quantity of resources available strongly influences the value of CMI. It is vitally important that some of the resources

available cover specific behaviors. A CMI student studying FORTRAN, for example, cannot reasonably be expected to study a textbook chapter on algebraic expressions when he forgets whether addition or multiplication operations are executed first. A simple instructive paragraph would be much more satisfactory. Appraisal of the resources available, the possibility of acquiring additional ones, and the flexibility of CMI prescription generators available is extremely important.

3. *Learning Center Location and Hours.* In a university environment, students may have access to a learning center at almost any hour. If this is true, an on-line system has many advantages in providing service to the student when he wishes. The location may not provide convenient access, however, and if not, it is highly important that upon arrival at the center, resources be ready and available. Certain combinations of location and hours make demands on the types of CMI services offered, such as scheduling, on-line or off-line testing, "mailbox" communications, and others.

Computing Services

Obviously, the computer hardware and software available dictate many of the constraints under which CMI must operate, but system modifications and additions may often be made which will benefit the CMI users. Systems differ in the extent to which educational system users become dependent upon computer center personnel and services. On-line systems require much more commitment to CMI from the computer center than do batch systems, but even within these two classes of systems there are differences in the degree to which data processing professionals must become involved. Local situations determine the degree to which such dependence is advisable. The advisability of carefully considering this factor can be attested to by many frustrated CMI proponents.

Nothing destroys CMI more rapidly than the negative attitudes developed by students trying to cope with an unreliable system. Service reliability is important in determining whether to implement CMI at all as well as determining what kind of system to use. Again, on-line systems are, for example, much more sensitive to the quality of service than are batch systems.

Many other factors in this category such as hours of system availability, turn around time, possible communication speeds, and type of mass data storage available are just as important as those discussed above, but simply cannot be itemized here. The statement should be made clear, however, that the nature of computing services available is as important an environmental factor influencing CMI as any of the others.

Administration

As a part of the educational environment, academic administrators exert both direct and indirect influences on CMI outcomes. Certainly policies of giving professional recognition for instructional innovations in general and for those using computer technology in specific have much to do with the future of CMI in a given institution. CMI is not always cheap (although there are dramatic demonstrations of its ability to reduce training costs) and it is not minor part-time activity (although systems differ greatly in the time and effort required for course implementation, operation, and monitoring). Administrative support of CMI is indeed necessary but not sufficient for success.

Administrative demands for instructional accountability, constraints on student/faculty ratio, needs for instructional cost reduction, and values for individualized education should (and often must) be considered not only in considering whether to use CMI, but also what criteria should be used in selecting a suitable system design. CMI systems are often designed for the ideal environment which, for example, permits a student-variable learning period and supports a fixed minimum achievement criterion. Administrative requirements, on the other hand, permit variable student learning within a defined time period at the end of which a performance grade must be produced. Such a system design and educational environment are simply incompatible, and some kind of adjustment must be made. For this environmental factor just as for all the others identified in this paper, it is well worth the effort to consider the possible effects it will have on CMI before a specific system is implemented.

References

Allen, M.W., Meleca, C.B., and Myers, J.A. *A Model for the Computer Management of Modular, Individualized Instruction.* Clarion, Iowa: Allen Printing Co., 1972.

THE MILITARY ENVIRONMENT FOR CMI

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The military environment is very conducive to the development of CMI. In general, the necessary ingredients are already in existence. There are five major considerations.

Centralized Facilities

Schools and training centers have been established where similar kinds of training and education take place. For example, Army communications subjects are taught at the U.S. Army Signal Center and School, Ft. Monmouth, New Jersey; Army medical subjects are taught at the Academy of Health Sciences at Ft. Sam Houston, Texas; Basic Airman training is taught at Lackland Air Force Base, Texas; foreign languages are taught at the Defense Language Institute, Washington, D.C.

Full-Time Learning

Students go to school for a scheduled eight-hour day. There is variety in the schedule—not all eight hours are lectures. Any training day might contain a variety of lectures, demonstrations, practical exercises, laboratories, and individualized study and research time. Going to school is considered a part of one's job in the military.

Defined Jobs

In the Army, the Military Occupational Specialty, referred to as an "MOS," is a job. All MOS's are defined by a job description that is valid Army-wide. The other services call their jobs by different names, but the concept is similar. These "jobs" range from technical skills to broad administrative and professional activities.

MOS-Producing Courses. These courses train students to perform the job skills necessary for performance on the job.

Non-MOS Producing Courses. These are professional courses for career persons, for skill advancement within an MOS and for covering general topics that are independently required of a specific job.

Instructor Development

Unlike almost all postsecondary education and training institutions, the military actually teach subject matter personnel "how-to-teach" in the service environment. The Faculty Development Course at the Academy of Health Sciences, for example, teaches the potential instructor how to write student-oriented instructional objectives. He is then taught how to organize instructional content within a chosen method of instruction for designing lesson plans that will allow and facilitate the students' learning. The instructor candidate is then taught how to evaluate student performance. Further, he is taught how to communicate to the student from the platform as an instructor. Instructional quality is also monitored after the training course with feedback given to the instructor for the purpose of self-improving his instruction wherever possible.

Course Design

Courses of instruction are designed through what are called "Systems Engineering" procedures. This is a formal procedure for making a course of instruction as effective and efficient as possible. At the Academy of Health Sciences, for example, the following procedures are used.

Task Analysis. The required tasks are analyzed to determine content and sequencing requirements. Some skills are selected for training, others will be required as prerequisites, and some will be deferred to on-the-job training.

Evaluation Plan. An evaluation plan is specified and is designed to evaluate the students' performance level and the effectiveness of the instruction.

Instructional Controls. The systems engineering procedures facilitate the development of a Program of Instruction (referred to as the POI) which completely defines the content of a course of instruction. Lesson Plans (referred to as LP's) are then designed and written by individual instructors to cover all of the scheduled hours in the POI. These lesson plans are reviewed as to their adequacy in facilitating learning so students can accomplish the required objectives.

Quality Control. The instruction that takes place is highly efficient and effective in accomplishing learning of the required knowledge and skills. Through the systems engineering processes the evaluation continues, making sure the graduate can perform on the job, and that both the job holder and the supervisor are satisfied with the work being performed.

THE INDUSTRIAL SCENE: A POTENTIAL BONANZA FOR COMPUTER-MANAGED INSTRUCTION

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Unlike its academic counterpart, industrial education and training are at best sidelines of the nation's business organizations and are, with limited exceptions, hardly the reasons for these organizations' existence. Therein lies the rationale behind many of the observations made below in briefly discussing the characteristics of industrial education and the potential adaptability of independent study techniques (i.e., computer-managed instruction) to the industrial scene.

To industry, the education and training function represents an expenditure of no small magnitude, at times exceeding the budgets of leading state universities. From the standpoint of instructors, most of whom did not receive their baccalaureate training in teacher education, and their associated salaries, there are few industrialists who would not delight in being able to turn over their complete education requirements to education institutions if this move were possible. There are, however, a number of characteristics of the industrial training requirements and a small set of limitations of academic institutions which together inhibit that transfer. Let's observe those characteristics.

Industrial Curricula

Industrial curricula tend to be specialized, dealing with the unique products or services rendered by the various firms. Economies achieved by offering a single course to a large student body centered at a single site are seldom present. Compounding the problem is that economies gained through repeated offerings of the same course over extended periods are not present. The reason for this conclusion lies in the fact that industrial education and training is product-oriented and it is common for product lines to be dynamic, thus requiring frequent curriculum changes. Not only do the objectives of the education and training experience change, but so do the reference materials associated with the courses. Some of the nation's leading industries virtually become small volume publishers out of necessity, unable to take advantage of the economies associated with large volume text output, an advantage seen in the more stable academic course areas.

Demands on the industrial education system also tend to be a bit foreign to those placed in a traditional academic institution. Industry does not run on an academic semester or term basis. Rather, it must be prepared within reason to provide education on demand. Where high turnover of employees is common and new-hire programs are constantly in place, few industries can afford to have trainees unproductive for weeks waiting for the beginning of a formal course. This economic concern is shared with the military to some extent.

The need for on-demand training more often than not results in small group education. Where traditional classroom instruction methods are used to satisfy the requirements of these small groups, the salaries of both the instructor and the students combine to make staggering cost for education expenditures.

Contributing to the inability of professional educational institutions to handle the education and training requirements of industry is the frequent occurrence of little advance notice of the need for a training requirement to be fulfilled. The latter is simply the result of an industry's attempts to respond to market variables which result in increased/decreased production output and product line changes. Both of these may require education redirection in maintaining a knowledgeable workforce. And then there are the employees themselves who frequently do not resemble next fall's incoming freshman class at the local university.

Industrial Students

What are industrial students like? Their academic background may be that of a high school dropout to professionals with multiple doctorates. In age and experience with a particular industry, the range is wide and diverse. The same can be said of learning abilities present in the workforce. Organizations which decline to train the older employee in new technologies find themselves top heavy with highly paid, semi-nonproductive administrators. As wide as their age and experience spread may be, the industrial employees do have one common bond. They are motivated by dollars. Where an education opportunity presents itself and is recognized as an opportunity to secure those dollars, that opportunity will not be ignored, but at the same time not necessarily capitalized upon unconditionally.

The industrial employee wishes his/her education opportunities to be convenient and not cause undue hardship. Labor unions frown upon "homework" and often insist upon overtime pay if after-hours study is required. And then there are peer concerns. The industrial employee may decline a highly desirable educational opportunity if the learning environment could put him or her in an embarassing position in the presence of peers or management. Once having chosen an instructional opportunity, the industrial student will usually place a number of personal demands on the system being used. Since the output of the course could directly impact salary, quality education is of great importance. Although the media is of importance as it relates to peer concerns and convenience, the message represents dollars. To assure themselves that learning is taking place and will have staying power, the industrial trainee demands feedback and tends to be print-oriented. He or she will invariably evaluate class effectiveness to some degree on the amount of reference and follow-on resource material supplied.

With this student profile in mind, the reader could conclude that an independent study system such as computer-managed instruction could offer much to industrial education and training. That might be a bit preemptive, however, if one fails to examine what industrial management looks for in an education system. They too are dollar-oriented, with the profits of the corporation chiefly under consideration.

Industrial Management

What does turn management on relative to education? Unlike most academic institutions, industry places a dollar value on their "student's" time. Although management would prefer that all of their employees' time be invested directly in producing goods and services, they recognize the importance of investing time in education—but as little as possible. If, through the proper investment of that time, the morale of their workforce is improved, management is quick to recognize the indirect value of sound instruction in increased output and decreased personnel problems. Rarely will sound management imply that they are not interested in improving the quality of the education produced by their training departments, but with the same rarity will they say that that interest is their major one. If a new methodology will maintain the company's current level of education at reduced cost with increased availability of a motivated workforce for direct productive activities, that technology is certain to gain attention in an industrial setting. But, possibly nothing more than attention will be gained unless transition to the new method appears feasible.

Conclusions

Having described in brief the environment of industrial education and training, the concerns of management relative to the significance of instruction technology, and the profile of the industrial learner, the writer suggests that independent study techniques in general and computer-managed instruction in particular offer much toward meeting the needs mentioned above.

The track record for the successful introduction of instructional technologies requiring radical changes of current educational systems has been a poor one, although admittedly far more impressive in nonacademic environments than within academe. Technologies requiring extensive curriculum preparation formats, such as programmed instruction and tutorial CAI, have been slow to take hold. Where entry costs have been high because of the insistence upon specialized computer hardware and software, only the researcher with hands and hat extended has been able to scale the barrier. Nevertheless, where entry has been made via the computer in industrial settings, the success of the technology as a manager of instruction dissemination and as a prescripter of education has gone for the most part unchallenged. Although the conclusion could be premature, there is data to suggest that CMI has a significant role to play in industrial education and may represent a road to the successful use of some of the more exotic technologies which have been slow to activate and of which CMI could be a fundamental part.

PART II

DESCRIPTIONS OF OPERATING CMI SYSTEMS

Reported by	Project Title	Target Audience	Hardware	Number of students in current application	Number of courses and Subjects
Dr. Thomas H. Anderson University of Illinois at Urbana	A Multifaceted Computer-Based Course Management System	Undergraduates	CDC 6400	530 students in 3 semesters	1: Introductory Economics
Dr. Frank B. Baker University of Wisconsin Madison, Wisconsin	The Sherman School CMI Project	Grades 4-5	UNIVAC 1100	165 students	1: Mathematics
Dr. R. Louis Bright Baylor University Waco, Texas	An Instructional Information System	Grades 7-12	PDP-11	141 students 1 secondary school	Manages grade contracts & schedules of all secondary school courses
Dr. Terry A. Countermine **Dr. Jane M. Singh** The Pennsylvania State Univ. University Park, Pennsylvania	ISS – Instructional Support System	Undergraduate & Graduate Students	OPSCAN 17 Texas Instruments cassettee terminal IBM 370/168	800 students/term	6: Children's Literature Computer Science Counseling Learning Disabilities Mathematics Educ. Reading Methods
Ms. Jan Danford Capital Area Career Center Mason, Michigan	Capital Area Career Center	Grades 11-12 Vocational Education Students	UNIVAC 70/2	1,000 students	23 Occupational Programs
Mr. George A. De Hart Westinghouse Learning Corp. Palo Alto, California	PLAN – Program for Learning in Accordance with Needs *Contact:* Dr. John C. Flanagan	Grades K-12	Computer Processing: IBM S/370 155 Remote Terminals: IBM 3735 Hewlett Packard 2100 minicomputer	60,000 students	Language Arts Mathematics Science Social Studies

Figure 2. SUMMARY OF 27 OPERATIONAL CMI SYSTEMS

Reported by	Project Title	Target Audience	Hardware	Number of students in current application	Number of courses and Subjects
Dr. James N. De Nio University of Kansas Medical Center Kansas City, Kansas	KUMC Test Question System	Medical, Nursing, Pharmacy students	OPSCAN 17 IBM 370/145	approximately 254 students	1: Pharmacology
Dr. B. Ward Deutschman New York Institute of Technology Old Westbury, New York	EMIS – Educational Management Information System *Contact:* Dr. Harvey Pollack CISS – Computerized Instructional Support System *Contact:* Dr. Alan Rosenblum	Undergraduates ——— Grades 7-12	Xerox SIGMA 6	400-600 students ——— 1000-1500 students	1: Intro. English ——— 4: English, Reading, Social Science, Mathematics
Dr. Karen A. Duncan Medical University of South Carolina Charleston, South Carolina	CMI in the College of Dental Medicine	Dental students	PDP-11/20	160 students/cycle	4: Dental
Dr. William P. Gorth Center for Education Research University of Massachusetts Amherst, Massachusetts	Comprehensive Achievement Monitoring	Any instructional enterprise	IBM 360/65 Minicomputers: Hewlett Packard 2000F Digital 11/45	varies	as appropriate
Dr. Harry Hsu University of Pittsburgh Pittsburgh, Pennsylvania	A Computer-Based Instructional Management System for Elementary Schools	Grades K-5	PDP-15	247 students 1 elementary school	1: Mathematics
Dr. Kirk A. Johnson Naval Air Station Millington, Tennessee **Dr. G. Douglas Mayo** Memphis State University Memphis, Tennessee	Navy CMI System	Navy technical trainees	Xerox SIGMA 9 OPSCAN 17 CDC 713-10 Display Terminal CDC 713-120 Thermal Printer	15,000 students	3: Aviation Mechanics Fundamentals, Aviation Fundmtls., Electrical & Electronic Fundamentals

Reported by	Project Tit e	Target Audience	Hardware	Number of students in current application	Number of courses and Subjects
Dr. Wilson A. Judd University of Texas at Austin	CMI at the University of Texas at Austin	Undergraduates	IBM 1500 CDC 6600 Texas Instruments Silent 700 terminal	300 students	1: Educational Psychology
Dr. Henry T. Lippert Academy of Health Sciences U. S. Army Ft. Sam Houston, Texas	Project ABACUS *Contact:* Col. G. B. Howard Ft. Gordon, Georgia	U. S. Army trainees	GTE Sylvania MMS multiminicomputer system	(development stage)	3: Avionics Communications Equipment Repair Field Radio Repair Teletypewriter Equip. Repair
Mr. Gerald Lippey IBM Corporation San Jose, California	CTSS – Classroom Teacher Support System	Grades 10-12 Undergraduates	IBM 360/50	500 secondary teachers sent to 24 colleges	History (grades 10-12) Test data banks in 9 college courses
Dr. Joseph I. Lipson University of Illinois at Chicago Circle	CMI Application in Chemistry	Undergraduates	IBM 370/158	100 students	1: Chemistry
Dr. William Lord Colorado State University Ft. Collins, Colorado	CMI Application at Colorado State University	Undergraduates	CDC 6400	390 students	2: Slide Rule Instruction Vector Algebra Concepts
Dr. Paul F. Merrill Florida State University Tallahassee, Florida	CMI at Florida State University	Undergraduates	CDC 6500	6,000 students annually	60

Reported by	Project Title	Target Audience	Hardware	Number of students in current application	Number of courses and Subjects
Ms. Katherine Morgan Montgomery County Public Schools Rockville, Maryland	Computer-Managed Geometry in the Montgomery County Schools	Grades 9-12	IBM 1500	6,138 students 6 high schools	3: Geometry Arithmetic Programming Languages
Ms. Ruann E. Pengov College of Medicine Ohio State University Columbus, Ohio	CMI Activities at the College of Medicine, Ohio State University	students of Medicine, Nursing, and Allied Medical Professions	IBM 370/158	60 institutions using OSU College of Medicine CAI materials	40 medically-oriented subjects
Dr. Robert J. Seidel Human Resources Research Organization Alexandria, Virginia	HumRRO CAI	U.S. Army Personnel Computer Programming Trainees	IBM 370/145	200 students	1: COBOL Programming
Dr. Lawrence M. Stolurow State University of New York at Stony Brook	TEST-AID – *Contact* R.L. Brennan SCORE – *Contact* D.D. McMullen CAI Laboratory – *Contact* B. Weneser	Undergraduates – – Remedial for Undergraduates	IBM 370/155 – – IBM 370/155, OPSCAN 100, IBM 1500	– – – – – –	as appropriate – – Essentials of Math., English Composition, Statistics Lab.
Mr. Peter S. Winters IBM Corporation Raleigh, North Carolina	IBM Field Instruction System *Narrative summary not available*	IBM Field Engineers	Mainframe: IBM 370/ Terminals: IBM 2740 IBM 3270	500,000 student days in 6 years (1 student day = 6 hours)	523
Dr. Joseph Y. Yasutake Lowry Air Force Base Denver, Colorado	AIS – The Air Force Advanced Instructional System	Air Force technical trainees	CYBER 73-14	2,100 students/day	4: Inventory Mgt. Materials Facilities Precision Measuring Equipment Weapons Mechanics

MULTIFACETED COMPUTER-BASED COURSE MANAGEMENT SYSTEM

Thomas H. Anderson
University of Illinois/Urbana

The Course Management System (CMS) was designed to integrate books, computers and live teachers in an effective manner. The system is intended for courses with large numbers of students and instructors, such as introductory courses in community college, university, or military settings. The logistic problems associated with multifaceted instruction programs and large numbers of students and faculty were solved, in part, by using a Computer-Assisted Instruction (CAI) system.

In the managed course, students are expected to acquire basic information concepts primarily from individual reading. Their attention to the material is maintained and their progress monitored by a previously developed and evaluated study management system, SMS (T. Anderson *et al.*, 1974). SMS intermittently questions the student about what he is studying so as to maintain deep cognitive processing. In practice, the student signs in at a computer terminal and receives a brief study assignment in his textbook. Upon completing the assignment in a nearby workspace, the student again signs in. This time he receives a short quiz over the assignment just finished. The cycle starts again with the next assignment.

Lectures and standard quiz sections are little used in CMS. The time of instructors, saved because routine lecturing and review are no longer required, is invested in remediation for students having trouble mastering the core curriculum, and in teaching a smorgasbord of topical, high interest, activity-oriented seminars and special projects. The role of the computer is to manage study behavior, administer on-line achievement tests, and schedule group tutorial and seminar sessions. The managed course features mastery learning and permits able, hard-working students either to complete the course in as little as 12 weeks or opt for extra credit by taking additional seminars.

CMS is being tried out this semester (Fall, 1974) in an introductory economics course on the college level with 360 students. To date, achievement data support the contention that students can acquire basic information from individual reading. Students are scoring as well on achievement tests as did students in previous semesters with lectures and discussions. In addition, according to questionnaire data, students like the seminars and their high seminar grades indicate that the students are performing well.

PLATO IV, an interactive CAI system, is utilized in the project. Terminals are located in the Undergraduate Library, foreign language building and College of Education building. During the first, second and third semesters 70, 100 and 360 students, respectively, participated in CMS experimental courses.

CMS was designed by the Departments of Psychology and Economics of the University of Illinois. The Advanced Research Projects Agency of the Department of Defense and Navy Personnel Research and Development Center funded the project. (Contract No. N61339-73-C-0078) Additional information and project demonstration are available by contacting Dr. Thomas H. Anderson, 226 Education Building, University of Illinois, Urbana, Illinois 61801 (217/333-8287).

References

Anderson, T.H., Anderson, R.C., Dalgaard, B.R., Wietecha, E.J., Biddle, W.B., Paden, D.W., Smoch, H.R., Alessi, S.M., Surber, J.R., & Klemt, L.L. A computer-based study management system. *Educational Psychologist*, 1974, **11**, 36-45.

Anderson, T.H., *et al.* An experimental evaluation of a computer-based study management system. *Educational Psychologist*, 1975, **11** (3), 184-190.

THE SHERMAN SCHOOL CMI PROJECT

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The Sherman School CMI Project is a cooperative effort of the Madison Public Schools and the University of Wisconsin. In 1969 the staff of the Sherman School developed the curricular plan and instructional model described below to individualize their mathematics program. In 1971, the CMI software was developed and used on a demonstration basis in the spring of 1972. Full operational use began in the fall of 1973. During the summer of 1974, a large number of refinements in the curricular plan, instructional model, and the computer software were made to incorporate the first year's experiences. The CMI project is currently in its second year of full scale operation involving seven teachers, two teacher aides, and 165 pupils. It is also in its first year of three years of support under Title III, ESEA. The funding will extend the use of the system to other schools and other curricula as well as transfer full responsibility of the computer component to the Madison Public Schools.

The CMI system is used to manage a combined fourth and fifth grade conventional mathematics curriculum. The subject matter of the two grades has been divided into 63 units of instruction, each having six objectives. The units of instruction are arranged in a linear structure with major topics appearing in a "spiral staircase" fashion. Review units appear roughly every five units. Each unit has associated with it a pre-test and three post-tests, each covering the six objectives of the unit. These tests are pencil-and-paper tests that are not amenable to machine scoring. Due to the linear structure of the curriculum, each unit has only one prerequisite. Locally prepared study guides in either printed or audio tape form are used to introduce a unit to a pupil. A variety of textbooks and locally developed materials are employed by a student to study the objectives of a unit.

The instructional model is analogous to a medical clinic where teachers perform specific functions and the pupils move freely from one station to another. During the mathematics period the complete second floor of the school is employed and the pupils in the seven classrooms merge into one group of 165 pupils. The basic instructional cycle begins with a pupil taking a unit pre-test that is scored on an objective mastered, nonmastered basis by a teacher aide. The test results are given by a pupil to another teacher aide who operates a computer keyboard terminal. The objectives not mastered by the pupil are entered and the computer generates a "tear-off sheet" that is given to the pupil. The sheet contains a list of seven prescriptions for each nonmastered objective and designates the computer-selected "best" prescription. Upon completion of the prescribed activity—typically problems from one of the textbooks—the pupil's work is reviewed by a quiz teacher who ascertains if the pupil is prepared to take the unit post-test. If not, the quiz teacher can assign additional prescriptions from the "tear-off sheet" and the cycle is the same as the pre-test. Mastery on five of six unit objectives results in a forward prescription to the next unit.

The instructional model employs rate of progress as the basic dimension of individualization. Due to the use of teachers in the testing room, study room, seminar room and as quiz teachers, each pupil has considerable teacher contact and individual attention under the model.

The instructional management philosophy focuses upon management of the unit cycle described above and upon managing the pupil's progress through the curriculum. Instructional decision-making and management decisions are based upon four different reports printed by the keyboard terminal. These are a Student History Report which contains a complete record of a student's instructional history, a Group Report listing pupils by homeroom and showing their currently assigned unit, an Objective Report listing the names of pupils working on each unit, and a Contact Report containing the names of pupils having no contact with the computer since a given date. It should be noted that the teachers have no grade books for mathematics and all information is stored by the computer. The reports are used to monitor student progress, detect patterns of pupil achievement, prepare report cards, and to evaluate the curriculum.

The computer software supporting the Sherman School CMI project is a general purpose CMI package called "Managed Instruction with Computer Assistance" (MICA). The software was conceptualized, fully documented and implemented by six graduate students as a homework assignment in a two-semester computer science course. The MICA program of approximately 6,000 lines of FORTRAN V was written for the Univac 1100 series of computers and employs a locally developed virtual memory capability.

The MICA software is highly modularized and access to its various capabilities is via a simple job control language. The computer-teacher dialogue is such that little training is required in order to use the system. The MICA software system is built upon a sophisticated data base management capability that supports the classroom use as well as the data base maintenance. The data base consists of five major files: Student History, Student Data, Group, Unit, and Prescription. Dictionaries containing the actual student names, prescriptions, etc. are used to provide a modified index sequential file scheme. Header records are associated with each file that describe the elements within a record. Documentation at the system concept and system design level have been written as part of the MICA development process.

The MICA software system is also being used to demonstrate the management of a modularized teacher education program via an interactive terminal.

The developmental cost of the MICA software was roughly $70,000. Operational costs for the first year were $2,000 for computer time, $2,000 of teacher time to develop the prescriptions, $3,000 to create the data base, and $5,000 of programmer time to maintain the system.

The Sherman School Project has been a classic example of iterative development of a sound underlying concept. There has been considerable interaction among the curricular plan, the instructional model, and the MICA software. The total developmental process has been under the direct control of the classroom teachers with the support of various specialists.

AN INSTRUCTIONAL MANAGEMENT INFORMATION SYSTEM

R. Louis Bright
Baylor University

The vision of an individualized school in which each student is progressing independently of any other, finishing and starting courses at any time and having the option of changing his grade contract or schedule whenever he wishes is the dream of many instructional technologists, but it conjures up a chaotic nightmare for most school administrators.

The objective of this information system was to rectify that chaos. It was developed for a totally individualized secondary school, grades 7-12, but it is also applicable to most individualized postsecondary situations.

The system to be described is not involved in instruction per se; i.e., it does not include CAI functions such as subject matter presentation or drill and practice—nor at the present time does it encompass any diagnosis or prescription. Such functions can be and are performed on the same computer, but as yet they are not integrated.

Why is such a system needed? My own rather extensive experience with individualized instruction has led me to believe that there are several important reasons, although some of them may cause my more liberal acquaintances who are proponents of unstructured education to label me as an arch reactionary.

In visiting numerous individualized programs around the country, I have become sensitive to the fact that in most of these institutions it is fairly common for a student to be making little or no progress, and no one is conscious of the fact that he is "lost." Consequently, I feel an urgent need for a system that will record and report on each student's progress.

Even though I am a staunch advocate of individualized, continuous progress educational programs, I cannot endorse the concept of "each student progressing at his own pace." Some students are seemingly quite content to make no progress at all. Rather, I believe that each student should have a goal—an individualized goal jointly agreed to by the student, his advisor, and his parents—and that his progress should be reported relative to scheduled progress toward that goal. The reporting system should generate exception reports which clearly flag the students who are significantly behind schedule.

Another somewhat controversial concept in secondary education is the "open campus." Personally, I don't think that most junior and many high school students are able to cope with that much "freedom." On the other hand, I do believe that it makes a great deal of sense to allow a student to make up his own schedule (with the approval of his advisor). Some students prefer to spend all day Monday on math, Tuesday on English; others may have all kinds of legitimate reasons for preferring one schedule over another and even changing it as special projects or activities arise. The advisor may also wish to schedule a student for more time in the English Department and less in the Science areas. The objective is to have a simple, manageable procedure for changing schedules at frequent intervals and then to have a method of checking to make sure the student is actually where his latest schedule indicates.

The "bugaboo" of many individualized learning programs is the tremendous record-keeping load that is imposed upon the teacher. Thus, another major requirement is that, insofar as possible, all the input should be generated by the student and not the teacher.

Most of the features of the system to be described were in operation last year on a remote job basis to the National Educational Computer Service. As a consequence of NIE's termination of support for that project, we are rewriting the package for a self-standing PDP-11 system. The scheduling component is now operable and we hope to again have the entire system by the end of the school year.

There are three major types of input. The first type builds the basic files of teacher names and numbers, student names and numbers, and course names, numbers, teachers, room location and any scheduling restrictions. These inputs are by conventional punched cards.

The second form of input is the schedule deck. Each student is issued a student card pre-punched with the student's number and a pre-punched card for each period in the week. The student then picks up a pre-punched course card for each course he is taking. Since our card reader can read either pencil marks or punches interchangeably, the student inputs his grade contract, the starting date, and the scheduled completion date for each course by marking the appropriate card locations on the course card. He then

assembles his schedule deck in the following manner: first, his student card; next a course card followed by all of the periods for that course, then another course card followed by all of the periods for that course, and so on until all of the course cards and period cards have been used. This deck then serves as the input to the scheduling program. The student can generate a new schedule simply by reshuffling the order of the cards in his deck. He will keep the same deck for all six years—adding or deleting course cards as appropriate.

These altered schedule decks can then be run either once a day or once a week as desired. The new schedule is printed out and becomes effective as of the following day.

As is essential with any student-generated input, there is extensive editing to ensure that all periods are used, that courses haven't been dropped without authorization, etc. The program also detects any course additions and prints out a course addition list for the appropriate teacher.

The third type of input is a "test card" that records the students' progress in their courses. A supply of test cards pre-punched with a student's name and number is stored at a convenient location. A student who wishes to take a post-test on a learning packet picks up one of these cards and marks on it the date, the course number, the learning packet numbers and his grade contract. He then presents this card to get his test and it is clipped to the test. When the teacher grades the test, he makes one mark on the front of the card to indicate whether or not the student met the passing criterion (usually 90%). He then writes any comments he may wish to make to the student on the back of the card. These cards are entered into the computer each morning and then distributed back to the students. Once again there is a very thorough editing routine that detects almost every conceivable error the student might make.

With all of this data in its files, the computer can generate myriads of reports. Some of the most important are the learning area rolls—for each period of the day, the report lists the students that are scheduled to be in each learning area and indicates for each the course that he is scheduled for and the number of days that he is ahead or behind schedule in that course. The area supervisor then knows which students should be closely supervised.

Similarly, weekly course lists are prepared for each teacher showing each student's progress relative to his own individual schedule and indicating when that student is scheduled to be in the related learning area. The principal gets an exception list indicating all those students who are more than some specified number of days behind schedule in a course. Obviously, many other types of reports and statistical analyses can be generated to assist in the management and improvement of the institution.

INSTRUCTION SUPPORT SYSTEM

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At The Pennsylvania State University in the College of Education, graduate and undergraduate courses offered with both computer-managed instruction (CMI) and computer-assisted instruction (CAI) are being used and accepted with a high degree of satisfaction. The two systems are being used jointly as well as independently depending on the type of instruction that the instructor chooses. Because of this dual role of computer technology in instruction at Penn State, an instruction support system (acronym ISS) has been implemented with the underlying implication that it is a large system using many different types of technology to support and/or manage instruction. Thus, Penn State has both an interactive data processing system (CMI + CAI) and a batch data processing system, both operating under the aegis of ISS. For example, one course (Language Education 441–Teaching of Children's Literature) utilizes the CAI system for measuring an individual student's competency in basic knowledge in six separate areas of children's literature, while it utilizes the batch data processing for daily feedback and weekly progress reports of all competencies, including those utilizing the CAI system. Other courses (Curriculum & Supervision 401–Test & Measurements, Counselor Education 425–The Use of Tests in Counseling, Mathematics Education 420–Teaching Mathematics in the Elementary Schools) use batch data processing only.

ISS is a system aimed to support individualized instruction. It has the flexibility to perform a variety of computation tasks needed for evaluative variants as well as individualized record-keeping and varied feedback control. Thus, while ISS has its origin in the College of Education, which initially felt a need to implement a competency-based teacher education program, it is a system which is adaptable to forms of instruction in any area at any level of complexity.

One of the underlying assumptions of individualized instruction is the diagnostic-prescriptive process. Penn State's ISS has this capability. The sophistication of the diagnostic-prescriptive process is primarily dependent on the instructor since ISS has a mapping flexibility of large proportions and can accommodate the instructor's prescriptions in both numeric and written language form. Feedback to the student concerning progress can be immediate, daily, and/or weekly, as desired. ISS is presently operating at Penn State in all three modes.

The standard ISS input form accommodates the variants described above. Once the input has been prepared the data are initially transferred by means of the OPSCAN 17, an auxiliary non-computer piece of equipment, which senses the darkest mark in a given area and sends out an appropriate signal to an external device. The external device in ISS is a remote-job-entry silent typewriter terminal with cassette tape capabilities. The data are thus transferred by means of the OPSCAN 17 to a cassette tape mounted on a Texas Instruments (TI) cassette terminal. It is then possible to edit the tape off-line to make any necessary corrections before sending the input to the computer. When the tape is ready, a telephone connection is made between the TI terminal and an IBM system 370 Model 168 computer. The data are then transferred from the cassette tape to a disk file connected to the IBM 370/. At the University Computation Center, these files are referred to as batch and terminal or BAT files. At this point the software of ISS (written in WATFIV, a version of FORTRAN) is executed and either a daily report or an accumulated progress report is produced depending on the instructional course design. The job is initiated from the terminal and the output routed to a high-speed printer.

The approximate cost for daily printouts from ISS per 100 daily transactions is $2 per day. At present Penn State has one course utilizing weekly progress reports in addition to the daily printouts. This weekly printout cost depends on the number of students. At present the one course utilizing this procedure has 142 students enrolled. A duplicate set is printed each week, one for the student and one for the instructor, and its operating cost for these 142 students is approximately $6 per week.

Computer-managed instruction in the form of ISS at The Pennsylvania State University is operating efficiently and effectively. Both students and instructors who are dedicated to quality instruction have found ISS indispensable to quality individualized instruction.

Jan Danford
Capital Area Career Center
Mason, Michigan

The Capital Area Career Center has developed a Computer-Managed Individualized Instruction program that addresses itself to three factors. We needed a curriculum and a system that:

- takes into consideration the competencies of each student in the selection of occupational training objectives, sequence of study, choice of materials and procedures,
- allows a student to spend whatever time he finds necessary in a given subject area as determined by his performance rather than by the clock, and
- measures each student's progress by comparing his performance with specific objectives rather than other students.

A Univac 70/2 Computer was used in essentially two ways: first, to analyze the data received from industry, and second, to manage the instruction. The first item, analysis of the data, was accomplished with the use of a technique of industrial job task analysis, sometimes referred to as critical incident studies. Representatives from industry and education designed job task analyses to determine what a person needed to know in order to perform each occupation properly. The five areas of competence scrutinized in the job task analyses were:

1. *Job Skills* – The observable, hands-on physical activity entailed in the job.
2. *Job Knowledges* – The knowledges or theories needed to perform the job function properly.
3. *Behaviors* – Job attitudes, behavioral skills required to get and keep a job.
4. *Basic Skills* – Identifying the exact arithmetic skills, reading levels, and measurement skills required by industry for each job.
5. *Equipment* – Analyzing all the equipment an individual must manipulate on each job and the proficiency required.

After all tasks were developed ("anticipated") for each occupation, they were given to persons in that occupation to determine a) whether it was or wasn't a skill needed, b) whether the task was an entry level skill, and c) the frequency it was performed in a given span of time. The resulting data gave us a list of accepted tasks and commonalities between occupations which was the basis for the curriculum. This initial phase required 131K of memory and 120 million characters of disk to manipulate the data.

The next important step was the writing of performance objectives for the accepted tasks, again based on industrial standards. Once that was completed, individualized learning packets were developed called modules to teach each skill spelled out in the objective. Each module consists of at least five things: the performance objective, the need-to-know data, materials and equipment, job steps, and a technical word list.

The Computer-Managed Instruction portion takes the information gathered from the task analysis and compares it with a student's competencies and occupational selection and provides an individual learning prescription. Each student goes through a basic needs assessment, checking his skills in reading, arithmetic, and pre-employment. If a student brings experience or training in a given occupation, he/she is given a hands-on test and that result is considered in the development and finalization of the learning prescription. Once the skills needed are determined, a sequencing of daily and weekly schedule is provided to each student. It schedules the student who has the severest basic skill (reading, math) deficiencies first into those areas and keeps track of their progress, moving a new student in when one has completed.

Every Monday each student gets a weekly schedule telling him what modules he will work on for that week. It lists the sequenced modules and all related information so the student knows where, who, and what. If the student works at a faster rate than anticipated and completes his "mods" early, he merely goes to one of the teletype terminals located throughout the building, activates the computer by punching certain information into it, and gets an immediate update of the next modules to be completed. If by the end of his Friday period he has not completed his modules, the incomplete modules appear at the top of the schedule for the following week.

The instructor, of course, evaluates whether or not a student has met the performance standards and conveys the information to the computer via a system using an optical scanner. While evaluation is continuous, a Cumulative Student Progress Report (CSPR) is issued every nine weeks. It compares the student's rate of quality productivity within the evaluation period with the total time available to the student, which is usually graduation, and indicates whether he/she will or will not complete (meet the occupational goal). As part of the total report, the instructor does a narrative evaluation which is printed on to the CSPR by the computer.

Finally, upon graduation from a program, each student receives a certificate of completion. It includes an explanation to employers and a list of tasks the student can perform and that we at the Center will stand behind.

As previously stated, a Univac 70/2 is used. We utilize DOS communication systems and a maximum of 60K is needed for the operations. The memory requirement for management systems is 96K based on a unique scheduling program. The system is written in COBOL and communications is Assembler. The Univac system consists of one control processor, 131K, 4 disk devices, 30 million bytes each, 2 30KB tape drives, one reader, one printer, one punch, and one communications controller with eight teletype lines.

PLAN: Program for Learning in Accordance with Needs

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PLAN was developed by the American Institutes for Research (AIR), under the leadership of Dr. John C. Flanagan, during the four year period 1966-1970. The project was to create a comprehensive program for the individualization of instruction in Language Arts, Mathematics, Science and Social Studies, K-12. From its inception the computer was always considered a major management tool. AIR early saw that the greatest value of the computer was in the management of processes, rather than tutorial, in an individualized program. Working with 14 public school districts, AIR continually redefined and implemented the computer management system during the developmental years.

Marketed commercially by Westinghouse Learning Corporation since 1970, PLAN has continued to use the computer as an essential component needed to manage an individualized instructional program. Currently (November 1974), approximately 60,000 students in 64 school districts in 24 states and one foreign country are using the system. The computer program has been and is being continually changed to reflect the needs of teachers and students.

Capable of supporting any objective-based curriculum, the WLC computer management system currently supports PLAN and locally developed programs with the following functions:

1. Identification and achievement level assessment of each student,
2. Identification and recommendation of the quantity of instructional materials needed,
3. Daily status reports of each student and planning sections for teachers and students,
4. Daily instructional objective test scoring,
5. Daily placement testing,
6. Daily PLAN achievement test scoring,
7. Periodic student progress reports,
8. Administrative reports,
9. Weekly summary reports,
10. On-line student progress reports,
11. History of student progress,
12. On-line ordering of additional materials,
13. Development of each student's program of study,
14. Processing of locally developed objectives, independent activities, and courses.

Most of the computer processing is done by WLC at Measurement Research Center in Iowa City, Iowa on an IBM S/370 155. The most common terminal used in the school districts is the IBM 3735 with an IBM 2956 Card Reader and an IBM 3288 Matrix Printer.

Increasingly popular as school terminals are the Minicomputers, which can provide services beyond the PLAN computer program. A Hewlett-Packard 2100 8K CPU with OMR Readers and Printers is most commonly used. A few schools are using their own IBM System 3.

Five school districts are now leasing the WLC PLAN software on local computers to manage both PLAN and local curriculums. This provides a locally controlled and economically efficient service using committed resources. The PLAN program, written in ANS COBOL, Version 4, requires hardware of at least 110K with 3 tape drives and 9-track dual density.

A COMPUTER-BASED TEST QUESTION SYSTEM

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Background

CMI first entered the scene at the University of Kansas Medical Center several years ago when a general revision of the pre-clinical Medical Pharmacology course was being planned. The overall objectives of the curriculum revision were 1) to permit each student to select the educational approach which is found to be most effective for him, and 2) to enable each student to progress through the course content at his own rate.

At the present time the pharmacology course is divided into five independent modules or units and the material in each of these modules is available to the student through a variety of scheduled (lectures, labs, discussion groups, clinical conferences, etc.) and nonscheduled (CAI, AV, tutorials, ward rounds, etc.) options. In addition, a syllabus has been prepared which outlines the material covered in each module. Each student can utilize as much of the material in each option as he needs to achieve his objective, which is to demonstrate competence (pass an exam) in the area covered in each of the five modules. New exams for each of the five modules are provided weekly, and since there is no penalty associated with failure to pass an exam, the student is encouraged to use the exam as a "progress yardstick." He is aided in this evaluation by a diagnostic identification of weaknesses.

Computerized support of Pharmacology's Computer-Assisted Teaching System (CATS) is now being maintained by the CAI/CMI section of the Department of Health Sciences Education. Three subsystems have been developed to support CATS. These are: the KUMC Test Question System (VH Programs), the Exam Grading/Analysis System (LR Programs), and the CAI System (IBM Coursewriter II).

KUMC Test Question System

This system performs test item pool management functions and generates examinations. The Department of Pharmacology currently has over 11,000 items in their pool. Using this pool they are able to generate from 3 to 8 unique examinations each of the 17 weeks that the course is in progress. The test item pool is stored on an IBM 3330 disk and can be updated from a terminal or in batch mode. Examinations can be generated by calling specific items or by random selection of items within a category. Examinations are printed on the system printer ready for duplication. Selector cards are retained on file in the various departments for each item in the pool. These cards contain the correct answer, category designation, item type and item analysis data. A test report is run on a proposed test prior to test generation to provide the test coordinator with information about the distribution of items over categories, item type and correct answer, and the projected level of difficulty and discrimination. This information enables him to make necessary changes to the test before the final run and eliminates many potential errors that are often made in the preparation of an examination.

Exam Grading/Analysis System

Students taking examinations respond on answer sheets that are read by an optical scanner (OPSCAN 17) and transmitted directly to disk on our IBM 370/145. A series of batch programs are used to score the examination and provide reports to students and the faculty on the results. Each student receives a letter giving him his grade, the correct answers to the examination, his answers, whether his score was superior, satisfactory or unsatisfactory, evaluation of performance on the various categories covered by the exam, and his progress to date in the course. Absent letters are sent to students not taking an exam in a given week to serve as a motivator. Unit chairmen within the department receive several reports. These include a listing of the responses of the students who took the exam, item analysis of each item used in the exam, and student performance by category. The unit chairman also receives a report listing the status of all students in his unit as well as a performance analysis based on the highest score each student received in the unit. The test coordinator for the department receives a report of each student's performance during each week of the course.

EDUCATIONAL MANAGEMENT INFORMATION SYSTEM AND COMPUTERIZED INSTRUCTION SUPPORT SYSTEM

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EMIS

The Educational Management Information System (EMIS) consists of a series of sophisticated programs and files which can administer, monitor and record individual student work in subject matter review drills and tests. The study and test material may be presented to the student either on-line or as computer-printed hard copy prepared in advance. The intention of EMIS is to provide a large number of objective questions of all types to serve as criterion checks and achievement indicators.

EMIS, designed by Dr. Harvey Pollack, is a combination of CAI and CMI. The EMIS presentations are supportive and supplementary to classroom instruction, self-paced individualized study, laboratory experiences, and auxiliary audio-visual aids. In the on-line mode, every student's response is evaluated and recorded for future statistical analysis and the student receives his score immediately after completing the bank of questions for that topic.

EMIS is a chained assembly of a number of computer programs and files. All of these have been written in extended BASIC so that they may be loaded into any large computer or minicomputer with minor modifications. Currently, the EMIS programs are running on a Xerox SIGMA 6 computer, operating under Universal Time-Sharing Operating System.

EMIS produces reports for the student, instructor, and curriculum designer. Each user has access to specific course information predetermined by the EMIS developers to ensure material security and test integrity. The reports offer: records of individual student progress, analysis of individual performance for remediation, records of cumulative class progress, analyses of strengths and weaknesses in question categories, cumulative item analyses, and indications of the existence of trouble flags.

CISS

The Computerized Instructional Support System (CISS) keeps track of a student's progress throughout his course work giving immediate correction of tests, remedial prescriptions if needed, and ascribes some measure of rate of progress to an individual's work. The system also functions to collect information on the validity of testing material, and the effectiveness of the course material. The Automated Instructional Management System (AIMS), which provides prescriptions to the learner based upon the accomplishment of specific objectives, is the progenitor of CISS and EMIS. CISS is a group of related programs and files which provides on-line correction of tests, issuing of remedial prescriptions, marking of attendance cards, generation of reports on individual student progress, query of history of responses for any student, and updating of test answers and student information. The system provides off-line editing and reporting of responses captured during on-line operations, data analysis of curriculum materials, and creation, maintenance and backup of data files. Dr. Alan Rosenblum is the designer of the system.

CISS uses a teletype-like terminal and an optical mark reader, acoustically coupled via telephone to a time-sharing computer. The system consists of three data files and the programs which access them. The data files consist of the Student File containing identifying information about each student, the Test File containing test answers and prescriptions, and the Response File which stores all transactions. The programs have been written in interactive COBOL and are running on a Xerox SIGMA 6, operating under UTS.

EMIS is used as an instruction support system for postsecondary teaching at the New York Institute of Technology, and CISS is currently utilized in a local junior-senior high school to enhance English, Social Science, and Mathematics instruction.

COMPUTER-MANAGED INSTRUCTION IN THE COLLEGE OF DENTAL MEDICINE

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In 1972, the College of Dental Medicine at the Medical University of South Carolina embarked upon a program of developing a self-paced dental curriculum. The program included the concept that the computer was indeed a useful if not an essential tool in its development. Accordingly, following a study to ascertain the best method of integrating computers into the curriculum, plans were made for the acquisition of a time-shared minicomputer system which would be used exclusively to enhance the educational experience of the dental students.

System acquisition, a PDP-11/20 using the RSTS operating system, was completed by July 1973. The efforts of the staff of the newly formed Office of Computer Resources have been in the areas of Computer-Assisted Instruction and Computer-Managed Instruction equally. While the long range goal of a totally self-paced dental curriculum can be met in large part by using traditional CMI techniques, the most pressing problem for management in the dental curriculum is in the area of student-patient clinic assignments.

A dental curriculum is similar to a medical curriculum in that the students spend approximately half their time studying basic sciences with lectures and laboratories and the other half of their time actually seeing patients in a clinic setting. However, unlike the medical curriculum where students are assigned to a specific clinic and may or may not see a patient with a given disease, the dental student must meet a list of clinical requirements. That is, the students must actually see patients with a predetermined set of conditions. This structure requires the dental school to assume the administrative chore of locating a large pool of patients from the population of the community and keeping a record of the treatment needed on each of these patients. It is an obvious extension to use the computer to maintain the patient files as well as a file on every student and the kinds of treatments that students need to carry out or have already carried out for purposes of grading. Thus the major goal of the Office of Computer Resources in the next two years is to complete the building of the patient file and the student file. This includes maintaining records, from both the student and patient point of view, of every treatment which is completed, each treatment which is in progress, and treatments which are yet to be done. This allows an up-to-the-minute progress review and grading scheme for the students and prevents incompletely treated patients' records from getting lost for whatever reason. The system will further involve keeping track of patient appointments and clinic utilization.

The clinical assignment system described above is presently well underway in its development. In addition, an extensive didactic grading system has been developed. At present this grading scheme addresses course grades rather than modules.

COMPREHENSIVE ACHIEVEMENT MONITORING: DECENTRALIZED, FLEXIBLE COMPUTER-MANAGED INSTRUCTION

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Focus

Comprehensive Achievement Monitoring (CAM) is an evaluation methodology with associated computer hardware and software which falls into the rubric of Computer-Managed Instruction (CMI). At a general level, evaluation methodology has as its purpose: "To provide information upon which a specified decision-maker is able to base decisions." CAM is an evaluation methodology especially designed for instructional situations because it is criterion-referenced, flexible, and computer-assisted, and provides information for decision-making. CMI systems are designed to provide information about students' performance to teachers or students upon which they are able to base decisions about future instructional activities. Therefore, CAM is an evaluation methodology many of whose components and uses are associated with CMI. CAM will be discussed as an evaluation methodology below.

CAM has been systematically developed, from 1967 to 1969, at the Research and Development Center for Teaching, Stanford University, and from 1969 to the present at the Center for Educational Research, University of Massachusetts/Amherst. It is conceptualized in 12 major steps, each of which is thoroughly documented in numerous operational substeps. An analogous Generalized Evaluation Methodology developed by Thomas E. Hutchinson and others (Hutchinson, 1972) has contributed to the refinement of CAM. The 12 steps include:

Step 1. The *Enterprise*—that aspect of the instructional situation (such as an individual student, a group, or the curriculum) about which decisions are to be made and, therefore, about which data are to be collected—is defined by the person initiating the evaluation.

Step 2. The *Resources* available for the evaluation are specified by the person initiating the evaluation.

Step 3. The *Decision-Maker*, who makes decisions about the enterprise and to whom data are to be reported, is identified by the person initiating the evaluation. (More than one decision-maker may be chosen. The decision-maker may be an individual, a group, or a collection of people. The initiator may or may not be selected as the evaluator.)

Step 4. The *Goals* of the enterprise are elicited from the decision-maker by the evaluator but not stated by the evaluator.

Step 5. The *Objectives* associated with each goal are elicited from the decision-maker by the evaluator but not stated by the evaluator.

Step 6. The *Decisions* to be made about each objective are elicited from the decision-maker by the evaluator but not stated by the evaluator.

Step 7. The *Measurement Technique* (or items) is developed by the evaluator or the decision-maker and is criterion-referenced—i.e., related to an individual objective.

Step 8. The *Design*, consisting of "which measurement instrument to be administered to which subjects on what schedule," is created by the evaluator and approved by the decision-maker. The design usually includes multiple matrix sampling.

Step 9. The *Collection* of the data is carried out by systematic logistics procedures.

Step 10. The *Analysis* of the data collected is performed quickly and flexibly by computer to the specifications set by the evaluator and approved by the decision-maker.

Step 11. The *Report* of the data is printed by computer and submitted to the specific decision-maker for whom the evaluation was designed.

Step 12. The *Revision* of the CAM evaluation is considered by the decision-maker.

The methodology has been described in detail by Gorth, O'Reilly and Pinsky (1974) and in a number of technical reports. The CAM evaluation techniques have been instituted in many schools across the country, at all grade levels and for many subject matters including special education (Gorth & Hambleton, 1973).

Instructional Dependency

CAM is designed to provide a specific decision-maker with criterion-referenced information

about a specific aspect of the instructional situation. Regardless of whether the decision-maker is a student, a teacher, or an administrator, of whether the enterprise is a student, a group, or the curriculum, of whether the decision to be made is concerned with planning, determining current status, or retrospective issues, the evaluation begins with the enterprise that the decision-maker specifies from his own perspective in terms of his goals and their related objectives. The measurement technique is written from the objectives. Therefore, there is always a close relationship between the objectives of instruction and the criterion-referenced measurement instrument.

Objective and Item Generation

The decision-maker is responsible for specifying his goals, objectives, and decisions (to be made) for the enterprise. The process may include the selection of objectives from the bank of objectives provided by the CO-OP (1972), but only after a set of goals and preliminary objectives have been defined. A numerical indexing system is assigned to the objectives. However, CAM could be used with existing objective-based programs such as IGE, IPI, IMS, and PLAN.

The test items are generated from the objectives by the decision-maker, if he is a teacher, or by the evaluator, if the decision-maker is an administrator. A computer-based system for objective and item storage and test printing has been developed to facilitate a rapid, flexible, and accurate construction of numerous test forms from the criterion-referenced test items (Gorth, Allen & Grayson, 1971).

Test Model and Packaging

After the test items have been generated, the assignment of the items to test forms and the scheduling of what students are to be tested with which test forms on what schedule (i.e., the design) is determined by the decisions the decision-maker wishes to make (O'Reilly & Gorth, 1972).

The designs created to collect data for each of these decisions may use any of several alternatives. However, the multiple matrix sampling design is often used, wherein a set of test forms is prepared, each form containing a sample of items representing all the objectives taught in a particular portion of a course. The set of test forms is administered in a "time series" design at regular intervals, but in such a way that no student takes the same test form more than once during the series of test administrations. The use of such a design for a science curriculum evaluation has been described by Hambleton, Gorth & O'Reilly (1973).

Test Scores

Computer programs have been designed to score, store, retrieve, analyze, and report criterion-referenced information collected using multiple matrix sampling and a time series design. The enterprise may be a student, a group of students, or a large and complex curriculum. Reports may be selected by the decision-maker from a variety which are available (Gorth & Grayson, 1969; Gorth, Grayson & Lindeman, 1969; Gorth, Grayson, Popejoy & Stroud, 1969; Gorth, Grayson & Stroud, 1969).

Reports are available to produce information about each of the following enterprises:

a. *Student Report* containing identification information, student's score on each objective, total scores, and indication of the objectives for which instruction has been completed.

b. *Teacher Roster* containing the students' names and both total score and score on objectives completed for all test administrations to date.

c. *Group Summary* containing average scores on each objective or group of objectives for a portion of a class, all of a class, all of a building, or all of a district at each test administration to date.

d. *Grouping Guide* containing students below criterion on an objective.

e. *Prescription Guide* containing a listing of related exercises for each student for each objective.

f. *Item Analysis* containing difficulty indexes before, immediately after, and a delayed time after instruction.

g. *Curriculum Analysis* containing pre-instruction, post-instruction, and retention averages for objectives.

The CAM system has been used in several Title III projects; it is also the system providing the evaluation design for the New York State system called the System for Pupil and Program Evaluation and Development (SPPED), developed by Robert P. O'Reilly.

Computer Hardware

CAM computer software was originally written for an IBM 360/65 computer at Stanford University and was considered a research system rather than one which could be implemented by schools. More recently, adaptations of the original software have been written for "mini" computers such as Digital 11/45 and Hewlett-Packard 2000F. The smaller computers and their associated computer software have allowed the decentralization of activities, but have used the standardized procedures at the decentralized sites.

Additional information is available from William P. Gorth, Ph.D., Center for Educational Research, School of Education, University of Massachusetts, Amherst, Massachusetts 01002 (413/545-1537).

References

CO-OP. *Catalog of Behavioral Objectives and Criterion-Referenced Test Items.* Amherst, Mass.: Author, University of Massachusetts, School of Education, 1972.

Gorth, W.P., Allen, D.W., & Grayson, A. Computer programs for objective and item banking. *Educational and Psychological Measurement,* 1971, **31**, 245-250.

Gorth, W., & Grayson, A. A program to compose and print tests for instructional testing using item sampling. *Educational and Psychological Measurement,* 1969, **29**, 173-174.

Gorth, W., Grayson, A., & Lindeman, R. A computer program to evaluate item performance by internal and external criteria in a longitudinal testing program using item sampling. *Educational and Psychological Measurement,* 1969, **29**, 181-183.

Gorth, W., Grayson, A., Popejoy, L., & Stroud, T. A tape-based data bank for educational research or instructional testing using longitudinal item sampling. *Educational and Psychological Measurement,* 1969, **29**, 175-177.

Gorth, W., Grayson, A., & Stroud, T. A computer program to tabulate and plot achievement profiles of longitudinal achievement testing using item sampling. *Educational and Psychological Measurement,* 1969, **29**, 179-180.

Gorth, W.P., & Hambleton, R.K. Measurement considerations for criterion-referenced testing and special education. *Journal of Special Education,* 1973, **6**, 303-314.

Gorth, W.P., O'Reilly, R.P., & Pinsky, P.D. *Comprehensive Achievement Monitoring.* Amherst, Mass.: The CO-OP, University of Massachusetts, School of Education, 1974.

Hambleton, R.K., Gorth, W.P., & O'Reilly, R.P. An application of an evaluation model for classroom instruction. *Journal of Educational Technology Systems,* 1973, **2**, 117-131.

Hutchinson, T.E. Some overlooked implications of the purpose: To provide data for decision-making. Paper presented at the meeting of the American Educational Research Association, Chicago, April 1972.

O'Reilly, R.P., & Gorth, W.P. Alternatives to accountability: Stool pigeon versus servant and soulmate. *Planning and Changing,* 1972, 13-24.

PROJECT ABACUS

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Mission

The primary mission of Project ABACUS is to procure, test and evaluate a computerized training system tailored to the needs of the Army. In addition, the Product Manager advises the Commander, U.S. Army Training and Doctrine Command (TRADOC) on matters related to computers in training, acts as consultant to the Department of Army Staff, participates in the PLATO IV Project sponsored by the Advanced Research Products Agency, serves on the ARPA Educational Technology Advisory Panel, and maintains liaison with other Department of Defense agencies and civilian institutions. On July 1, 1974 the Product Manager's Office (PMO) was additionally charged with the development of a Long Range Plan for TRADOC Training and Schools, proponency for TRADOC subgroups on Policy and Procedures and Tactical Application of Computers and the Supervisory Management of the Combined Arms Tactical Training Simulator (CATTS) at Ft. Benning, Georgia.

Objectives

Employing three Army training courses, the project aims to achieve the following:

1. Cost effectiveness – through reduction in training time, decrease in failure rates, streamlining of training management, use of small-scale computers, and provision of a base for rapid expansion.

2. Training effectiveness – by individualizing instruction, incorporating the best of existing media and relieving the instructor of routine administration.

3. Technical efficiency – through utilization of off-the-shelf equipment.

Background

In June 1972 the Vice Chief of Staff of the Army, based on recommendations of a task group, approved Project ABACUS. This approval included the following stipulations: use of small-scale computers, concentration of expertise at a single location, use of three training courses, and a maximum of four years duration.

Selection of Ft. Monmouth as the site for the management office was based on the existence of expertise developed there during an earlier successful project. In that experiment, utilizing 102 hours of basic electronics, over 1,300 students received instruction by means of the computer. A summative evaluation comparing results gained from students in the project with those of conventional classroom students showed a 35% reduction in training time, a 21% decrease in attrition, an equivalent academic achievement, and a highly favorable attitude toward computerized training.

Conduct of Training

Under the Computerized Training System concept, instruction will be individualized from beginning to end. Each student will progress through a course at his own pace.

To accomplish this goal, the instructional personnel and the computer must function as a team. The instructional personnel will prepare lesson materials, monitor performance, supervise laboratory work, and provide direct assistance. The computer will maintain records, guide student activities and present portions of the instructional material. In this manner a reduction in overhead personnel is considered feasible.

The need for group activity is not overlooked. Lectures, demonstrations, conferences and team exercises will be included, as appropriate.

Evaluation

Evaluation of Project ABACUS will consist of two major elements. The first will be designed to provide quality assurance of course materials, while the second will form the basis for recommendations for the future.

Although both elements of the evaluation will be accomplished by in-house personnel, consultants will be called upon from time to time to advise in specific areas and thus ensure validity of the findings. The final report will include an analysis of the results weighed against objectives of the project, i.e., cost effectiveness, training effectiveness, and technical efficiency.

Status of Procurement

On December 26, 1973, a contract was awarded by the U.S. Army Computer Systems Support and Evaluation Agency to GTE Sylvania Inc. for a 128 terminal multiminicomputer system (MMS). A GTE Sylvania information bulletin defining the utilization of

the system is available.

A 32-terminal display controller subsystem was delivered to the U.S. Army Signal School (USASIGS), Ft. Gordon, Georgia on July 29, 1974. Upon completion of the subsystem test and acceptance, it will primarily be used to support course material development and on-line entry utilizing available CLASS I authoring commands.

The remainder of the system to include software and CLASS I language is scheduled for delivery by March 1975. Following the acceptance testing of the 128-terminal system and the CLASS I authoring language, course material validation and systems debugging will take place. It is anticipated that the CTS will be operational with the first course by August 1975.

Course Development

The U.S. Army Signal School Computerized Training System was initially established in January 1974 and its participation on the ABACUS Project consists primarily of the development and administration of three technical training courses on the CTS provided by the Product Manager. The courses, the first of which is scheduled to be operational by August 1975, are: MOS 31E20–Field Radio Repair, MOS 31J20–Teletypewriter Equipment Repair, and MOS 35L20–Avionics Communications Equipment Repair. Progress in course development by the task group has been significant. In addition to a seminar held at Ft. Monmouth for course leaders, several workshops have been conducted for course instructors and consisted of workshops on the instructional model and teaching strategies, the CLASS I authoring language commands, and lesson development techniques and procedures. Presently course development of the three courses is actively underway.

A COMPUTER-BASED INSTRUCTIONAL MANAGEMENT SYSTEM FOR ELEMENTARY SCHOOLS

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An ideal individualized instructional system usually includes four phases of activities: 1) diagnosing student characteristics and assessing student achievement, 2) storing and retrieving student data for decision-making, 3) prescribing instruction according to students' needs, and 4) instructing students, using the most appropriate method. The computer-based instructional management system described here attempts to employ the assistance of a computer in all four phases of the instructional process. This computer assistance includes: computer-assisted testing (CAT), information retrieval, the instructional option display (IOD), and computer-assisted instruction (CAI). Although the use of the computer in instruction is an integral part of an instructional management system, this component can initially be developed independently and implemented as an option for instruction. Therefore, the role of the computer in instruction will not be discussed here.

In order to explore the possibility of using the computer to administer achievement tests, a computer-assisted testing model was developed. This model was designed to generate and administer pre-tests, post-tests, curriculum-embedded tests (CETs), and exercise pages (practice problems) for all skills included in a unit. Based on this model, six experimental programs were written for E-Level IPI Math in Numeration/Place Value, Addition/Substraction, Multiplication, Division, and Fractions (comparable to third and fourth grade math). These programs were implemented during the past two years (1972-1974) to study the feasibility of CAT as an alternative for testing, the strategy of item generation, the characteristics of items generated by a computer, the establishment of rational mastery criteria, and the impact of CAT on students' attitudes toward math and computer testing.

To process test and instructional data, an on-line information retrieval system was developed and implemented at the Oakleaf School beginning in the Fall of 1973. This system was designed to be used by teachers, supervisory personnel, school administrators, curriculum developers, test constructors and researchers. The types of data collected and maintained include: 1) information concerning students' backgrounds, 2) test results, and 3) instructional tasks prescribed. Although the system was designed for data in various subject areas, only math data for about 200 students from grades one through five were collected and stored in the data base during the 1973-74 academic year. During the 1974-75 school year, two classes in kindergarten were also included in the data base.

This information system can be divided into four major components: 1) data gathering and verification procedures used by aides to enter data using the Datapoint 3300 at the end of each school day, 2) backup procedures performed by programmers at LRDC before running the UPDATE program, 3) updating of temporary files into the permanent data base, also done by programmers usually the next day, and 4) retrieval and reporting routines prepared for users. There are two types of retrieval routines: 1) standard reports and 2) the QUERY programs. In standard reports, the types of variables to be printed and the output formats are predetermined. In the QUERY program, the values to be listed and the output formats are specified by the user at the time the program is run. Both types of routines are designed for on-line retrieval through terminals. Preliminary reactions from teachers and researchers in using this system are extremely favorable.

The instructional option display is a new adventure just launched at LRDC. Programming of the IOD model using Unit E-Division of IPI Math is underway. Field testing of this model is expected to begin in the Winter of 1975. The purpose of the IOD is to display available instructional options and to suggest a sequence of learning according to the computer or paper-and-pencil pre-test results. Based on this display, students may choose the option for study by themselves or with the teacher's guidance. Another purpose of this display is to replace hand-prepared prescription sheets in order to facilitate the process of data entry through terminals.

The computer used for developing the management system is a DEC PDP-15, a medium-scale, general purpose, multilanguage, time-sharing system, which is housed in a van located at the school. This experimental time-sharing system (ETSS) includes 32K

N.B. The research reported herein was supported by a grant from the National Science Foundation (NSF) and by the Learning Research and Development Center, supported in part as a research and development center by funds from the National Institute of Education (NIE), U.S. Department of Health, Education and Welfare. The author wishes to thank all past and present staff of the project and other colleagues at LRDC who have contributed to the design, development, and implementation of the management system.

words of memory, memory protection-relocation hardware, a 1 million word drum storage unit, three IBM 2314 equivalent disk drives, two DECTAPE drives, paper tape equipment, four internal clocks, telecommunication equipment, and a terminal controller capable of controlling 64 terminals of which 32 are currently installed. Users access this system through remote terminals on a telephone dial-up basis or through terminals at the computer site, which are directly wired to the machine. In addition to the management system, ETSS also supports CAI efforts in spelling and mathematics.

Although CAT, information retrieval, and IOD were developed independently, our plan is to integrate them into a complete computer-based instructional management system. The initial phase of integration has begun in the design of IOD_f which will use CAT results or data available in the information system to select the appropriate options to be displayed. The next step in the integration is to develop a program for transferring CAT data into the permanent data base. Another major concern in our future development is to make the management system more generalizable to other subject areas, other school settings, and other computer systems.

The implementation of the management system has numerous important implications. In addition to the effect on students' learning processes, a favorable modification of the role of teachers in the classroom can occur. Instead of lecturing and maintaining students' records, teachers should be able to devote more time not only to the process of providing individual and small group guidance, but also to the selection of instructional and testing material. Another even greater impact of the system is related to the work of evaluators and researchers. Evaluators and researchers need not be overwhelmed by an unmanageable amount of data. When reasonable questions are formulated with a proper regard for the data maintained in the management system, evaluators and researchers can obtain accurate information and answers arranged in a meaningful manner.

NAVY CMI SYSTEM

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The Navy Computer-Managed Instruction system became operational in the Summer of 1973, in two courses at the Naval Air Technical Training Center, Memphis, following a research and development effort that took place over a period of six years. Additional courses are being added and the system has been extended by means of telephone lines to the Naval Training Center at San Diego. A CMI terminal is being installed at this time at the Naval Training Center, Great Lakes, but large scale use of this extension of the CMI system is not planned for the immediate future. To date, approximately 15,000 students have received at least one week (30 hours) in CMI learning centers, shops and laboratories. At any given point in time, about 1,500 students are under instruction.

The Navy CMI system was developed with computer hardware located at Memphis State University. At the present time, the hardware configuration includes as a central processing unit a Xerox Corporation SIGMA 9 with 256K characters internal storage, with 8 removable disk packs with a total of two million characters of storage. Four of these drives are dedicated to the CMI files. One 9-track 800 BPI (bits per inch) magnetic tape drive is used for storage of backup files. The input/output function is handled by an interactive time-sharing terminal which consists of a cluster of three pieces of equipment. Initial input into the system is made by means of an Optical Scanning Corporation OPSCAN 17. Each scanner can handle approximately 100 interactions of the type required per hour. The second piece of equipment is a Control Data Corporation 713-10 Conversational Display Terminal. The output device is a Control Data Corporation 713-10 thermal printer, which has a capacity of approximately 30 characters per second.

The usual student input into the system is in the form of answers to questions that are designed to measure the specific objectives of the course. The student often is reasonably sure that he knows the answer to the questions involved because of the immediate feedback feature that is built into the instructional material when it is developed. So it is not unusual for the input into the computer to be primarily a matter of confirmation to the student that he has, in fact, achieved the competency in question, and also for the purpose of making it a matter of record in the system. The computer can be very specific in its feedback to the student, however. In an instance in which the student has input answers to a 50-item test, for example, specific comments and instructions can be given concerning any one or all of the items. As a rule, the student will have more than one module of instruction on which to work, so that any delay in the availability of the terminal or in the computer's response to his input will not result in his being delayed in achieving the objectives of the next unit of instruction.

The terminals at all three Naval Training Centers (Memphis, San Diego, and Great Lakes) are connected by telephone lines to the SIGMA 9 computer at Memphis State University. Other hardware configurations were used during the R&D project, but did not prove to be as effective as the one just described. The primary characteristic that differentiated the earlier configurations from the present one was that they utilized batch processing terminals instead of the interactive type terminal that is being used at the present time. At different times during the R&D project, the Memphis State University Computing Center had automatic data processing systems other than the SIGMA 9. One of these was an IBM 360/40; another was a Xerox SIGMA 5. While some adjustment in the computer software was involved each time the data processing equipment was changed, CMI did run on all three of the systems. The Navy has been working toward procurement of its own computer to support the CMI system since the time the system was approved as operational. It is expected that this computer hardware will be delivered next spring.

The Navy CMI system is programmed in a standard programming language that is usable in a number of computers produced by different manufacturers. The primary programming language is COBOL—hence, the programs will run with relatively minor adjustments on most machines for which a COBOL compiler is provided. The basic CMI computer software package was developed for the Navy under a contract with Memphis State University. Features of the package include: extensive test, evaluation and record-keeping capabilities; the option of presenting comments and detailed remedial material; and generation of optional individual reports. In addition, history files are maintained that allow course optimization through periodic analysis of student performance and response patterns.

N.B. The views expressed are those of the writers and are not necessarily concurred with by the Department of the Navy.

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Terminal-Oriented Interactive System

The College of Education's current CMI system was developed for two purposes: to support individualized instruction used in conjunction with an undergraduate educational psychology course, and to provide an instructional context for research on affective variables. The system's development and the research conducted were supported primarily by the National Science Foundation. Only the instructional aspects will be discussed.

In cooperation with the course instructors, five topics were identified and a self-instructional module was developed for each topic. Each of the modules (Computers in Education, Classroom Management, Statistics in the Classroom, Tests and Measurement, and Cultural Differences) was designed to require four hours of a student's time and consisted of a series of readings with behavioral objectives and corresponding sample test items. Most readings were selected and edited. Some were written locally. With reference to Bloom's taxonomy, all modules included objectives at the knowledge and comprehension level, three included application level objectives, two included analysis objectives, and one included evaluation level objectives. Two parallel forms of a criterion-referenced multiple choice test (15 to 20 items per form) were developed for each module. The tests, diagnostic protocols and prescriptions were programmed in Coursewriter II for the IBM 1500 computer. A disk-oriented data management system was developed to permit timely generation of instructors' reports.

Following a manual pilot test in the summer, the system was implemented for the fall semester of 1972. Materials and tests were revised between semesters and a summative evaluation was conducted in the spring of 1973. During the four semesters of its use, approximately 8,900 tests were administered.

Each course instructor could select the modules to be used in his class, determine the sequence in which modules were to be studied, the mastery criterion for each module, and the dates by which students were to complete each module. During the first class week, students were given a handout describing the procedures to be followed and discussing the effective use of behavioral objectives. They purchased the instructional modules at the University bookstore.

When ready to take a module test, a student made an appointment by telephone for a one-half hour block of terminal time. At the time of his first test, he was given a brief computer-assisted tutorial on using the terminal. He signed on with an assigned number, was shown his own name for purposes of confirmation, and was randomly assigned to one of the two parallel test forms. Test items were displayed on a CRT and students responded by typing the number of the selected alternative. No feedback was provided until the end of the test at which time overall score (percentage correct) and percentage scores on individual objectives were displayed. If the overall percentage was less than his instructor's criterion, he was required to take a retest on a subsequent day. If he did not meet criterion, the student was given a typewriter printout containing both the performance information displayed on the CRT and remedial prescriptions for the objectives failed. For the most part, these prescriptions were assignments to reread specific sections of the module. Retest items were drawn from the alternate to the student's initial test form and covered only objectives failed on the initial test. Final score was cumulative over the two tests. A student who failed to meet criterion on a retest was referred to his instructor for further work.

Two levels of reports were generated for the individual instructors. Module Reports listed both the class average and each student's test and retest scores on each objective in the module. Course Summary Reports covered all modules assigned to the instructor's class and listed students' current overall scores on each module. Sub-criterion scores and scores resulting from retests were identified. Both reports were generated from disk files and reflected test activity up to the moment. At the instructor's discretion, reports were either generated on demand via typewriter or on a periodic basis via line printer.

At the time of summative evaluation, the percentage of students achieving criterion (80% correct) on the initial module tests ranged from 36% to 80% (median = 69%). The percentage meeting criterion on either an initial test or a retest ranged from 77% to 96% (median = 91%). The Alpha reliability coefficients of individual test forms ranged from .56 to .81 (median = .72). Student responses to attitude scales administered following each module showed substantive improvement from the formative evaluation and were considered to be satisfactory.

The cost of developing the five modules, criterion referenced tests, and support software was approximately $11,500. This figure reflects 1972 salaries and does not include the cost of formative evaluation and subsequent revision. Operational costs were computed for the first 300 students completing four modules. Personnel expenses were $1,740; computer time charges, at $6.09 per terminal hour and $48.72 per hour for utility use, amounted to $5,810.

Mark Sense Card Interactive System

While providing satisfactory service, the system described is much too expensive. Consequently, a new system is being developed with the goal of reducing computer costs while maintaining the level of service. Since linear multiple choice tests appear adequate for most of our needs, testing will be moved off-line. The student will mark his answers to a pre-printed test on a mark sense card and then submit his card to a Hewlett-Packard optical card reader. Short FORTRAN programs resident in the University's CDC 6600 computer will identify the student, test number and form, score the test, and select the appropriate prescription. Feedback to the student will be printed at 30 characters per second via a Texas Instruments Silent 700 terminal. To reduce system time, student records will be dumped on tape and the data management system's files will be updated daily. With these exceptions, the procedures will remain essentially the same. In comparison to the operational costs cited above for 300 students studying four modules, it is anticipated that personnel costs would increase to approximately $2,200 (partially due to inflation) while computer costs would be reduced to approximately $1,000. These cost figures are presented primarily for the purpose of comparing the two systems discussed. Due to the various ways in which costs can be computed, the reader is encouraged to exercise caution in generalizing the absolute dollar figures to other settings.

CLASSROOM TEACHER SUPPORT SYSTEM (CTSS)

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CTSS was developed in 1969 and 1970 as an experimental application under a joint study agreement between IBM and the Los Angeles City Unified School District. It is available from the district and is now in use at several places, most of them institutions of higher education.

This application grew out of the recognition that the computer could perform an important function by relieving the teacher of clerical chores while leaving him free to make instructional decisions. It was regarded as a first step toward more sophisticated instructional applications.

CTSS uses a centralized data bank of questions on disk storage to aid teachers in constructing tests and exercises. The system also scores students' answer sheets. It operates in batch mode, with teacher requests, tests, and scoring reports transported physically between the teacher and computer center.

Items may be classified along several dimensions, including subject matter, difficulty, and behavior required. They are retrieved according to classification criteria set by the teacher. Thus, a list of questions may be constructed so that it contains, for example, a specified number of questions on each of several topics, with the desired mix of difficulty levels. Specific items may also be requested by their identification numbers.

The items selected are listed as an "exercise," which is assigned a number and remembered by the system. The teacher may specify that items be deleted or added to produce a new "generation" of the exercise. This process may be repeated for subsequent generations until the exercise meets the teacher's needs.

With each exercise, the teacher receives a list of the classification data for the items it contains. He may also receive references to two sources of published material associated with each question. A summary of the teacher's request and the items retrieved as a consequence is produced as part of the exercise.

An exercise may be printed on reproduction masters when desired. Also, upon request, the system will create several "versions" of the exercise with the items resequenced at random on each.

Answers to exercises are remembered by the system, so scoring keys need not be submitted. The teacher may add items of his own to be scored, and he may have self-constructed tests scored if he provides the answer key. Scoring of individual questions can be suppressed. The usual raw data, frequency distributions, summary statistics, and item response breakdown are provided to the teacher. Questions can be assigned to parts of the exercise, each of which will be scored separately (in addition to scoring of the entire exercise). If scrambled versions were used, additional reports for each version may be obtained.

For each item collection, there is an item statistics file which contains usage data for every question. The information contained in this file includes the number of times the question was selected by the system, deleted from an exercise by a teacher, and suppressed from being scored. The file also contains data obtained from scoring, such as the cumulative number of responses to each option and a central tendency measure of discrimination indices. A program is available to test selected statistics against specified thresholds to obtain a list of those questions likely to need revision. Thresholds can be set for high teacher rejection rate, low average discrimination index, unusually heavy use of a distractor, and very high or low measured difficulty level.

Information on system activity is accumulated in a system statistics file. This file contains data on 25 different kinds of activity, representing the use of various functions. The information is accumulated simultaneously for two time periods (long and short). It is classified by item collection used and by up to twelve groups to which teachers may be assigned. A printed activity report by item bank can be obtained at any time.

An assortment of additional programs is available for printing and updating item banks and other system files.

At least a dozen item banks are now in use by CTSS at various places, and others are under development. Other systems are also being constructed with CTSS as a model.

But CTSS is not the only set of programs which assists with test construction. The author is personally aware of over 70 different systems, and there are probably at least twice this many. Most of them make use of test items in machine-readable form to print questions on demand. Many include, as does CTSS, computer assistance in selecting the specific questions to be printed. Some systems can generate a very large number of similar questions by using random techniques to particularize a question "skeleton." A few involve computer assistance in the item selection step only, with the items drawn manually from file cabinets and the tests printed by conventional means.

There are many benefits realized by those who employ the computer to aid in constructing tests: centralized item collections that are shared gain all of the efficiencies of scale, including the advantages of specialization, larger question pools, and more feedback. Clerical work associated with preparing tests and exercises is of course reduced, and the quality of the printed product is usually higher. Since tests can be easily produced when required, they need not be collected after use; in fact, a new one can be prepared for each student, to support self-paced instruction. Compared to most other uses of computers in instruction, the cost can be very low. And because it can assist teachers having a variety of instructional approaches, computer-assisted test construction does not need to force change in long-standing classroom behavior patterns—while at the same time, it can support improved instructional behaviors.

References

1. Classroom Teacher Support System

IBM, *Preparation of Tests and Exercises at Los Angeles City Unified School District.* (Application Brief No. GK20-0508) White Plains, N.Y.: Author, 1971.

Lippey, G. A comprehensive question retrieval application to serve classroom teachers. In *Proceedings of the 1972 Fall Joint Computer Conference,* 1972, **41**, 633-639.

Lippey, G., Toggenburger, F., & Brown, C. D. Computer-based exercises aid classroom teachers. *Journal of the Association for Educational Data Systems,* 1971, **4**, 75-84.

2. Computer-Assisted Test Construction

Lippey, G. Computer-assisted test construction—a bibliography. Association for Computing Machinery *Sigcue Bulletin,* 1973, **7** (4), 22-26.

Lippey, G. (Ed.) *Computer-Assisted Test Construction.* Englewood Cliffs, N.J.: Educational Technology Publications, 1974.

CMI APPLICATION IN THE CHEMISTRY DEPARTMENT OF THE UNIVERSITY OF ILLINOIS AT CHICAGO CIRCLE

Joseph I. Lipson

Brief Description

A critical problem in individualized programs of instruction based on a mastery performance is the need for different versions of unit mastery tests. Often a student must take an exam several times. If there are only two alternate forms of the exam or only a small pool of questions used to form exams, then test security and test validity become serious problems for the course program. The University of Illinois at Chicago Circle has a large number of entering chemistry students with highly varied preparation for college chemistry. They are given a placement test and students who score below a certain point are required to take a course which covers basic concepts and skills which will enable them to function effectively in succeeding courses in chemistry.

When this course is administered by conventional lectures and discussion sections, the attrition rate is higher than we find acceptable and their ability to perform at the next level is not dependable. For this reason, Professors Kotin, Liu and Jameson developed a modified Keller Plan for the course. They call the new course Chemistry 107.

Computer-Generated Tests

To deal with the test problem, Dr. Cynthia Jameson developed a computer program which, using skeletons of various forms of questions, will generate—on demand—as many tests as are needed. Some students have used as many as eight exams for a single unit. (There are 15 units in the course.) In the words of the authors, "An aspect of self-paced instruction that is of paramount importance is the examination system. The examinations must be equivalent and repeatable and free of security problems. A system that contains a limited number of questions (though the number may be large) tends to encourage the students to build their own files and learn to anticipate the questions, to say nothing about the problem of keeping the master examination file secure. We solved the problem with the computer-generated question concept. The questions are not merely assembled by computer, but actually generated. Numbers in problems are randomly but logically generated. Chemicals and other variables are similarly selected. In addition, there are even different ways of stating the same problem. We have literally an infinite number of examinations—each different from all of the others. The exam system makes self-paced instruction a viable format."

Target Audience of Learners

The target audience is comprised of inadequately prepared students who need basic chemistry courses for their programs. In our case these are largely inner city students.

Principal Instruction Objective

The principal objective is mastery of basic chemistry concepts and skills (including some math such as scientific notation) which will enable the student to function in following course sequences.

Plan of Use

Exams are generated freely for students to use in self-testing and self-study. Exams are, of course, generated whenever a student is ready to take a unit mastery test.

Hardware Configuration

Hardware used consists of Selectric IBM terminal connected to IBM 370/158 by phone lines. Three terminals handle the course load of about 100 students.

The system is interactive.

Estimated cost is $100/month per terminal rental; total cost is about $1,000 per month. This means the cost is about $25 per student for the course.

CMI APPLICATION AT COLORADO STATE UNIVERSITY

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Background

The Computer-Managed Learning System Laboratory at Colorado State University has been in operation since April 1969 with support from the Control Data Corporation and the National Science Foundation. Initial project goals included:

1. Development of a centralized multimedia instructional delivery system with all media storage devices to be physically independent of the student stations.

2. Development of an adaptive teaching strategy based on sound learning principles and capable of interacting with each student on an individual basis as well as reacting to an accumulation of student performance data.

3. Design of a shared computer system capable of allowing CMI operation to exist with other university computer users.

A prototype, 4-student-terminal system was built in 1970 utilizing a variety of media devices and employing a teaching strategy based on a cognitive level/concept categorization of instructional modules. The prototype system has been thoroughly tested for operational integrity by some 90 undergraduate engineering and mathematics students studying 12 vector algebra concepts to the 'application' level of learning. Also, 300 engineering students have used the system for slide-rule instruction. At the present time, a second generation 70-student-terminal CMI system is in the design phase.

Specifics

A. Target Audiences – grades K-16.

B. Instructional Objectives – to provide the student with a variety of learning experiences, including information delivery and retrieval, drill and practice, tutorial, enrichment, examination, feedback, counsel and functional support including computation and simulation.

C. Hardware Configuration – currently eleven student terminals are connected to the University's CDC 6400 system computer.

D. Interactive or Batch – the CML system operates in an interactive mode, although students can manipulate batch programs via a special operating system.

E. Diagnostic or Prescriptive – the CML system provides both modes of operation by keeping records of student activities and making use of a decision algorithm and a correlation matrix relating various components of the instructional set.

F. Auxiliary Non-computer Equipment – includes an Ampex fast access video disk for video still-image storage, computer-controlled video tape players for 'mini-lectures' and a video-scan converter for student-generated graphics.

G. Estimated Cost – hardware costs 50-90 cents per student-terminal hour, depending upon amortization period of equipment.

References

R. W. Hayman and W. Lord. A technology-based educational system using computer management. *Educational Technology*, December 1972, **12**(12), 43-51.

W. Lord and R. W. Hayman. An adaptive teaching strategy for computer-based learning systems. Proceedings of the 1974 International Conference on Frontiers in Education, July 1974.

COMPUTER-MANAGED INSTRUCTION AT FLORIDA STATE UNIVERSITY

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The Florida State University has been involved with computer-assisted instruction since September 1964. The University has utilized several different computer systems in going from research and prototype applications to applications in regular university instruction. The computing system currently being used is a Control Data Corporation 6500 with five remote job entry stations and over 120 remote terminals including teletypes, teletype compatible cathode ray tubes and Tektronics 4013 graphic terminals.

The Center for Educational Design (CED) was formed as a service unit to encourage and assist the faculty in the systematic design and development of instructional materials. CED has assisted in the development of over 30 courses which utilize computer applications and service over 6,000 students annually. Although a wide variety of different computer applications are used in these courses, the major application is some form of Computer-Managed Instruction (CMI). A terminal-oriented CMI approach is used in over ten courses in areas such as Physics, Communications, Programmed Instruction, Business, Habilitative Science, and Religion. Approximately eight courses in such areas as Economics, Business, Geology, and Psychology utilize a batch-oriented CMI approach.

A computer program developed at Indiana University by Prosser and Jensen is used in our batch-oriented CMI courses. The program has been adapted by CED to allow the entering of parameters through an interactive terminal and the storage of regeneration decks and student data in permanent files on disk.

CED has also developed a library of FORTRAN and Assembler Language Subroutines which serve as the basis of a modular terminal-oriented CMI system. The general nature of these subroutines makes it possible to develop a CMI program which meets the specific requirements of a particular course with relative ease. For a given course a FORTRAN driver routine is written which calls the needed subroutines from the library. They, in turn, correspond to the capabilities to be incorporated into the CMI program. The pool of test items with their corresponding correct answers, feedback, and statements of objectives are stored in sequential disk files. Since these files are separate from the computer programs, it is possible for a secretary with no programming background to enter the test items into the computer through an interactive terminal. CED has also developed a program to translate these files into the format required by Prosser's batch-oriented CMI program and vice versa.

The following section will list a wide variety of options which may be incorporated into a course which utilizes a terminal-oriented computer-managed instruction approach.

1. All students may be required to take the units in a specified sequence or they may select the units in any order from a "menu." If one set of units is prerequisite to another set, the student can be required to complete the first set before being allowed to select units from the second set. Selection within a set may be in random order.

2. Pre-test data obtained by computer terminal or machine scorable answer sheets may be input and stored in computer files and used to make decisions concerning which units or objectives within units a student may exempt.

3. The test items selected for a given unit may be the same for each student or they may be randomly selected from each of several sets of items within a unit. Items on succeeding attempts for the same unit may be selected with or without replacement for a given student.

4. The feedback or diagnostic learning prescriptions given to the student may vary widely in type and amount. Feedback may be specific to a given response, a given question, a set of questions, a unit, or completed units to date.

5. The criteria for proceeding to another unit may be the same throughout the entire program or it may be unique for each unit or objective. The number of attempts per unit may be set by the instructor, and the student may be retested on all objectives within the unit or only on those objectives which he failed.

6. A record-keeping and report-writing facility is available which provides item analysis information for item revision and data on student progress through the course.

7. The student may be permitted to branch to a calculation routine and then return to the test item from which he was branched.

8. The student may be allowed to type in a comment after each test item or unit if he so desires. These comments may be sorted and printed for the instructor's use in revising the course.

9. A bulletin board option allows messages to be displayed to all users, to students within a given course, or to a specific student.

Additional information concerning computer-managed instruction at Florida State University may be obtained by requesting any of the following reports.

CED Report No. 1: *The Role of a Center for Computer Support of Instruction within the University*

CED Report No. 2: *Development of Computer-supported Instructional Activities for Individualized Instruction*

CED Report No. 3: *The Use of a Modular Programming System Adaptable to Various Instructional Needs*

CED Report No. 4: *Utilization of the Computer in Group Instructional Settings*

CED Report No. 5: *Critical Issues in Computer-Managed Instruction*

COMPUTER-MANAGED GEOMETRY

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The Montgomery County (Md.) Public Schools' Computer-Assisted Instruction Program has been in operation since 1968. One of the original goals of this program was to ascertain the role of the computer in testing and in test development. County mathematics teachers had been writing objectives and assessment items, developing hierarchies and gathering reference materials for a projected ten-unit geometry course for students who had successfully completed one year of algebra. This geometry course was intended to be individualized and, to that end, was piloted in paper-and-pencil form in a number of ninth and tenth grade classes. As originally implemented, it was a logistical nightmare. The amount and disposition of paper involved was staggering; most of the teachers' time was spent in assessing test items; students were frustrated as they lined up to get items graded, and to have a concept explained or a question answered.

An obvious solution would be a computerization of the assessment items so that teachers could handle the instructional tasks for which they are best prepared. A year-long computer-managed system seemed to be a logical mechanism for presenting items, scoring responses, providing prescriptions and keeping records. The concern of this program was not only diagnosis, prescription and assessment but, in addition, the continuous monitoring of individual progress. The definition of computer-managed instruction which evolved was the student use of remote time-sharing computer terminals to assure the attainment of specific behavioral objectives through the individualization of the instructional process.

The initial use of the geometry course began in the 1970 summer school session at Einstein High School. The test items for the first five units (Introduction to Logic, Geometry as a Mathematical System, Methods of Proof, Parallels and Perpendiculars, Congruence) were written, revised and coded for use on the IBM 1500 system. All instruction was off-line and did not normally involve the computer—although if a computer-assisted instruction package on a concept or skill were available, then that CAI module could be prescribed. The trial use of this system elicited such enthusiasm from both students and teachers that the CMI geometry was incorporated into the mathematics program for three classes in the fall of that year. The remaining five units (Similarity, Circles, Constructions and Loci, Coordinate Geometry and Areas and/or Volumes of Plane and Solid Figures) were coded during the next semester, making the entire CMI geometry curriculum available.

Upon entering the course, a student is provided an overview of the first unit, a list of objectives with a diagram showing the interrelationships of the objectives and their sequencing. Before beginning the study of a unit, the student could take an optional diagnostic test to determine which objectives he had already mastered. After ascertaining his entry level, the student studied clusters of related objectives keyed into several books. These books vary in their presentation by difficulty, sophistication and vocabulary. The activities related to the cluster of objectives might include teacher presentation of a concept, small group student interaction as well as readings, questions and problems assigned from a student-chosen textbook. Upon completion of assigned work, the student interacts with the terminal and receives feedback on each objective of the cluster. Alternate assessment items are available on each objective if a student did not succeed with the original assessment. If a student fails both the original and alternate assessment items on an objective, he is referred to his teacher for instruction or clarification. At the end of each unit, a test is randomly generated on the predetermined culminating objectives of the unit.

During the 1970-71 school year the program was validated to assure that it provided the management system it was intended to provide. The mathematics department then determined that with the support the program provided, they would increase the average class size in geometry classes during the 1971-72 school year. A year-long comparative evaluation study showed that with the 40% larger class sizes than in conventional geometry classes, there was no significant difference in achievement. In addition, a study was made to determine the amount of individual attention teachers gave students in traditional classes as compared with teacher-student interaction in computer-supported classes. The results, based on several thousand observations at random predetermined times by trained observers in a variety of matched mathematics classes, showed that CAI/CMI teachers provided their students significantly more individual attention than was possible in traditional classes.

Based upon the experiences of three years and the results of a number of studies, including those mentioned above, a recommendation was made to the

Superintendent and the Board of Education to provide CMI geometry to five additional senior high schools. The justification for this recommendation is that some of the program costs can be displaced through a 40% increase in class size with no significant difference in achievement. This recommendation, as well as several others, was adopted and CAI/CMI programs are being implemented in thirteen elementary and seven secondary schools during the current school year.

For further information, contact Katherine E. Morgan, Director, Computer-Assisted Instruction Program, c/o Einstein High School, 11135 Newport Mill Road, Kensington, Maryland 20795.

THE OHIO STATE UNIVERSITY COLLEGE OF MEDICINE OVERVIEW OF CAI ACTIVITIES

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The College of Medicine's Computer-Assisted Instruction (CAI) efforts have been concentrated in three major areas:

A. CAI as a supplemental teaching tool for use in connection with ongoing courses in the curricula for medicine, nursing, and allied medical professions.

B. CAI as a tool for providing continuing medical education for health professionals.

C. CAI as a tool for facilitating the independent study concept at the curriculum level in the teaching of basic science concepts to medical students.

The fruits of these efforts have been shared with other universities and medical schools. Currently, the University of Virginia is linked to the College of Medicine system. Many other schools have implemented College of Medicine materials on their own systems. This exchange is now facilitated via the College of Medicine Release Policy and, in addition, the College maintains one of two host computer systems linked to a nationwide CAI network for medical education. This effort is sponsored by the Lister Hill National Center for Biomedical Communications, National Library of Medicine.

Major CAI Usage Areas

A. *CAI as an additional teaching tool for use in connection with ongoing courses in the curriculum.*

Since 1964, The Ohio State University College of Medicine has been continuously re-evaluating and revising its medical education curriculum. Initial experience with independent study was acquired through the use of a two-track curriculum in Anatomy and independent study groups in Biochemistry. The College of Medicine has utilized computer-assisted instruction in segments of its curriculum since 1967, when CAI courses in Anatomy and Biochemistry were written to complement the independent study effort. Originally these courses were used by students as self-evaluation exercises. In Histology, a simulated laboratory experience on the CAI terminal has replaced actual laboratory in organ identification. CAI courses have been written in the intervening years to accompany many areas of study, i.e., Musculoskeletal System, Physiology, Neuroanatomy, Neuromuscular Morphology, etc.

Computer-assisted instruction within the School of Nursing is used primarily by undergraduates for primary learning, for review, and for optional learning opportunities in conjunction with established nursing courses. Students utilize courses such as MEDREC, VEINS, ORTRAC, PROSHK, MATH, PSYMED, UANDME, BOTTLE, AGENT, ACCESS, STRIPS and PACARE on a continuing basis.

Computer-assisted instruction within the School of Allied Medical Professions is used as a simulated laboratory experience for review and self-evaluation, and in the curriculum of the divisions of Medical Dietetics, Medical Records Administration, Occupational Therapy, Physical Therapy, Radiologic Technology and Respiratory Technology. Fourteen CAI courses are required for student usage in the allied curriculum.

In addition, the College software, hardware and personnel have been used in the past to support CAI developments in this category for the colleges of Dentistry, Pharmacy and Optometry. The College of Optometry continues to utilize the College of Medicine CAI system while Dentistry uses main campus CAI and Pharmacy has its own CAI system.

B. *CAI as a tool for providing continuing education for health professionals.*

The Computer-Assisted Instruction Regional Education Network (CAI-REN) is a statewide network of CAI installations. Participation in the network provides health institutions with readily available, individualized instructional materials for continuing education, planned curricula and inservice education.

CAI-REN utilizes telephone lines to connect remote terminals to the computer at the Ohio State College of Medicine. This hookup, available on a "round-the-clock" basis, permits all shifts to utilize the same mode of learning.

The CAI-REN course library is constantly available to the users. CAI-REN provides new courses on a regular basis. Periodic revision and updating of

materials necessitates occasional removal of courses, which are promptly reactivated after revision. Audio-visuals in the form of slides, audio-tapes and printed materials are incorporated to provide a complete learning environment.

Selected courses are approved by various professional societies for continuing education credit. These societies include the Ohio Osteopathic Association, the American Medical Association, the American Dietetic Association, the American Osteopathic Association, the State of Ohio Board of Pharmacy, and the Ohio Council on Medical Technology.

This membership-supported network consists of institutions of varying sizes representative of many geographic areas. Currently there are 15 participating institutions.

C. *CAI as a tool for facilitating student self-evaluation in a medical curriculum independent study program in the medical basic sciences.*

Work in this area has come under the auspices of the Independent Study Program (ISP), formerly known as the Pilot Medical School (PMS). The Ohio State University Pilot Medical School was a research project investigating the effectiveness and efficiency of utilizing independent study for medical student education. The charge which confronted the Pilot Medical School was to design, implement and evaluate a preclerkship curriculum that would incorporate as its foundation certain educational principles and tenets of independent study. The ISP was formed as a result of a three-year grant from the U.S. Public Health Service, Division of Physician Manpower. The grant provided for one year of program development followed by two years of operation and evaluation. The period of the grant was from June 1969 through June 1972, and the first class of 32 students began their medical studies under this independent study curriculum in July of 1970. The second class of 59 students began in July of 1971 and a third class of 64 students began in July of 1972. In 1972, the ISP became a College-supported curricular offering thus, medical students could elect this method of study for all their preclerkship education.

The lecture-discussion program is a four-phase, three-year (35 month) curriculum. The ISP is a nonlecture, student self-paced program for the basic science study, and is followed by 18 months of clinical rotations.

The concept of independent study means different things to different people; it encompasses a spectrum of individual interpretation and operational structure. The ISP does not employ computer-assisted instruction in a primary instructional role. The student's use of the computer is for tutorial self-evaluation—hence, the self-evaluation exercises were designed to provide the student an opportunity to gauge his own progress and determine his success in satisfying the objectives of the unit.

A Tutorial Self-Evaluation (TSE) program is available for each instructional unit (submodule). These exercises, currently catalogued under the access code "PILOT," were designed by the faculty to test comprehension of the instructional objectives for each submodule. Items in the exercises may be constructed as *response, true-false, multiple choice, matching* or *ranking* questions. The computer encounters the student with a question and then immediately evaluates his response. Correct answers receive a reinforcing type of feedback, while wrong answers trigger corrective feedback and another chance to respond to the question. The computer will also respond to unanticipated answers and attempt to coach the student, through a series of statements, to the correct answer. Of particular note are the different types of computer feedback provided by the author for the student's answers. The computer programs have also been designed to indicate to a student when he is not doing well on the TSE. In this instance, the computer will alert him to his deficiencies with study prescriptions. Study prescriptions may appear as an additional study assignment, a review of previously suggested materials, or a simple statement suggesting a faculty conference.

Several conditions were necessary for the ISP concept to even be considered. These conditions are still true today:

1. The OSU College of Medicine has a stable computer system which is operational 22 hours per day. The computer used is the IBM 370/158, housed in the Hospital Computer Center. The computer support personnel for CAI reside in the Division of Computing Services for Medical Education and Research. The staff has the experience and expertise necessary to handle CAI hardware and software problems, and to modify the coursewriter package to accommodate user needs. Expertise also exists in authoring

techniques, instructional programming and course development.

2. Additional expertise in strategies, design and usage of CAI exists within the Division of Research and Evaluation in Medical Education.

Recently Completed Efforts

Under a grant from the Lister Hill Center, the College has completed a link with a national telecommunications network (TYMSHARE) to make the College of Medicine's CAI materials available to users across the country. There are now 59 institutions in the United States using The Ohio State University College of Medicine CAI materials on a regular basis. Through this grant, 1) the University of Illinois "case" materials (which simulate the clinical encounter) have been loaded on The Ohio State University College of Medicine system for use by College personnel and network users, 2) authors at other institutions (University of Washington Medical School, University of Pittsburgh and Downstate Medical School) have developed CAI materials on The Ohio State University College of Medicine system, and 3) local users have had access to the Massachusetts General Hospital CAI materials.

Under a grant from the Bureau of Human Resource Development, the College is documenting and packaging the ISP materials. These should be available to medical schools and other potential users by Fall of 1974.

To facilitate sharing and to allow installation of quieter user terminals, all College CAI courseware has been converted from 100 character to 70 character lines.

Current Developmental Efforts

In addition to usage described above, the College is currently involved in several experimental and developmental efforts.

Under a grant from the Bureau of Human Resources Development, the College is developing curricular and test materials to extend the ISP concept to the clinical years of medical training.

Under a grant from the Bureau of Health Resources Education awarded to the Division of Medical Dietetics (School of Allied Medicine Professions), simulated CAI case studies of patient encounters are being developed. These materials are currently being utilized by medical dietetic students.

HumRRO CMI

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The CMI system developed by HumRRO is an outgrowth of Project IMPACT's approach to modularizing instruction in a CAI context.

Essentially, we have made provision for any course to be broken down into subsets of terminal and enabling behavioral objectives: The largest subset is called a Division (D), the smallest a "Module of instruction." A module may be thought of as a single concept and involves a Telling Section (T) in which the student is given the concept, a Practice Section (P) in which the student has hands-on experience in using or applying the concept, and finally, a Quiz Section (Q) that tests the degree of mastery by the student of the terminal objectives set forth for that module. Any or all of the sections can be administered on- or off-line. In our CMI version, Q remained on-line. (As applied to the COBOL 2 course developed at HumRRO, a module was completed, on the average, in approximately 15 minutes.) T and P sections were converted to hardcopy programmed instruction. This process was greatly simplified because the instructional module *text*, stored separately from instructional *logic*, could be directly printed out in a paged and readable format. In the CAI version, movement among these sections was accomplished via computer access and monitoring, whereas under CMI the student did this on his own and no record was made of such movement. In the COBOL 2 course, divisions formed a linear (complete) order; that is, students completed them in a fixed sequence. (This need not be the case with other courses of instruction where careful task analysis has shown that certain divisions can be achieved independent of the achievement objectives in other divisions.) Within each division of the course, modules form a partial order (a graph, a map) on which students or system could progressively *impose* a particular linear sequence or route.

The hardware configuration is a 360-370/145 (OS) driving Sanders CRT's and auxiliary projection devices. A 35mm hand-controlled Viewlex, a student reference manual and a glossary notebook replaced their on-line counterparts in our CMI mode. The learning environment is *Interactive. Diagnosis* in our instructional application was based on achievement of objectives in a given module (or in some cases, sections of a module). Our software is capable of considering performance over a range of modules by simply adding the desired criteria from the appropriate objectives. The on-line *Prescriptive* aspect of our course management, viz., the individual student progress, is accomplished interactively through interface (Underhill & Stelzer, 1972). IDES-2 (Willis & Stelzer, 1972) is a set of batch programs for monitoring and managing student and course performance.

IDES-2 has an advanced report generation facility that provides information for evaluating the instructional material and student progress. In addition, IDES-2 provides attendance reports, lists of student and proctor comments and opinions, and lists of informational requests made by students. Some IDES-2 reports are used by authors to standardize the labeling of instructional material and the assignment of error codes to student responses. Other IDES-2 reports summarize student performance, provide data on the adequacy of instructional components, and display cumulative data on students' paths through the instructional material. Some reports are provided daily and others are provided on demand only.

For administrative reasons, IMPACT students are run in groups. The reports generated by IDES are group-oriented and can be classified as being intended for administrative or authoring purposes. The administrative report and some authoring reports are generated on a daily basis. Other authoring reports are generated periodically, either on demand or after all students in a group have completed a course module.

A brief description of the daily reports generated by IDES-2 is provided in Figure 1. With the exception of the attendance report, all daily reports are intended primarily to be authoring aids. The student comment and proctor comment reports are useful in gauging student problems with the instructional material. The glossary report can bring to light confusion in terminology that may be developing because of incomplete instructional material. The label report is intended to be used to clear up any inconsistencies in the author's labeling of the instructional material. The response analysis verification report is intended to be used to ensure that response error codes are being assigned properly. Finally, the daily module acceptance analysis report provides data that are used to establish the adequacy of modules in terms of the pass/fail percentage. These data are used to accept or reject a module, thereby indicating where more authoring activity is required.

Report Name	Report Contents
Attendance	A list of all students in the group encountered on a given day showing the total amount of time each student has been on the course, as well as indicating each student's overall progress. For students in the group–but not receiving instruction on the reporting day–an absence is indicated showing the total number of absences.
Student Comment	A list of all student comments for the particular day indicating when and where the comment was made and by whom.
Proctor Comment	A list of all proctor comments for the particular day indicating when and where the comment was made and by whom.
Glossary	A list of all found, not found, and illegal glossary requests, indicating where the request was made and by whom.
Label	A list of Coursewriter labels that are apparently inconsistent with IMPACT coding conventions that have been encountered during the reporting day.
Response Analysis Verification	A daily report that shows for each question encountered on that day the number of correct and incorrect responses. The types of errors assigned to the errors are also listed.
Module	For each module encountered on the reporting day, data describing the pass/fail percentage on the quiz as well as an acceptance/rejection analysis.

Figure 1. GENERAL DESCRIPTION OF THE CONTENTS OF IDES-2 DAILY REPORTS

References

Underhill, W. & Stelzer, J. *Project IMPACT software documentation: IV. The interface subsystem framework for instructional decision modeling.* Research Product RP-D1-72-3, Human Resources Research Organization, Alexandria, Virginia, August, 1972.

Willis, L. & Stelzer, J. *Project IMPACT software documentation: II. The IMPACT data evaluation system–version 2 (IDES-2).* Research Product RP-D1-72-1, Human Resources Research Organization, Alexandria, Virginia, August, 1972.

SUMMARY OF CMI ACTIVITIES AT STONY BROOK CAI LABORATORY

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Many of the computer-based courses and course components developed at SUNY, Stony Brook were designed to operate in either CMI or "mainline" CAI modes, or a combination of both. The following brief descriptions should serve as examples of these programs.

Essentials of Mathematics

A computer-based student laboratory, designed to improve the basic mathematical skills of University freshmen who lack them, is currently being offered at Stony Brook.

The Essentials of Mathematics CAI course includes in its design a testing procedure so that the well-informed student, able to demonstrate competence in all the topics, sees the program as simply a set of tests. For other students, some or all of the lessons contain instructional modules. Although the lessons currently on the system provide for on-line instructional modules, plans for future lessons include off-line modules as well.

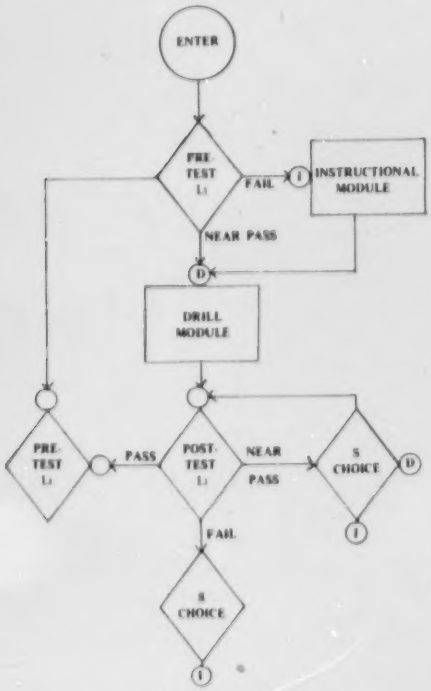

Figure 1. SAMPLE LESSON

Note that the drill module itself is of variable length (i.e., testing takes place within the module, with the number and type of drill items dynamically determined). The test items and the instructions and drill items are all computer-generated. The weekly student progress reports issued to instructors are part of the system.

English Composition

For the past five years at Stony Brook, we have provided a laboratory for those students who need remediation in some of the basic writing skills. The objectives are:

1. to provide drill and practice, as necessary for each individual student, in the elimination of common syntactical faults;

2. to give the student a sense of the structure of English sentences, the function of different syntactic structures within the sentence, and the way these syntactic structures work together to communicate information and create style;

3. to enable the student to attain mastery of stylistic alternatives;

4. to develop an understanding of the logical use of subordinators, coordinators, and other connectors; and

5. to develop the skills involved in self-editing of written productions.

The approach is structural and inductive rather than traditional or deductive. Definitions and rules are not emphasized. The student sees many examples of each concept and engages in constant activity related to them. He is allowed to discover his own "rules," those rules which help him make language work for him.

Each concept is preceded by a pre-test; if the student demonstrates mastery, he skips the exercises connected with that concept and proceeds to the next pre-test. During one semester, we experimented with a set of exercises in programmed workbook form following one of the pre-tests. The workbooks were generated using the textual material and computer program which generated the on-line exercises. The

feedback was, of necessity, not as complex, but the format was similar. Half of the students received their drill and practice for this concept on-line—the other half were given the workbook and returned to the terminal upon completion of the exercises. The purpose of this experiment was to determine if these composition lessons would produce equivalent results if given as CMI lessons rather than "mainline" CAI. Should the entire series be given in CMI form, each on-line pre-test would be followed by either the next pre-test, or by directions as to which workbook must be completed before proceeding. Results of the experiment are not yet available.

Statistics Lab

This one-semester computer-based homework review laboratory has been offered to undergraduate students in *Psychology* and *Economics* Statistics courses. Students use workbooks which contain, for each chapter, an introductory exposition (independent of any textbook) and a set of exercises (problem statements only).

The student reports weekly to the computer-based lab after having worked out the exercises for a chapter. The lesson at the terminal requires that the student answer each of the problems previously assigned in the workbook, and only when the student does not answer correctly does a tutorial-type exchange take place. At the end of each lesson (chapter), additional exercises are assigned in each of the topics in which the program detected that the student experienced difficulties. Other additional exercises, not in the workbook, are given "on-line."

THE AIR FORCE ADVANCED INSTRUCTIONAL SYSTEM (AIS)

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System Description

The AIS is a prototype computer-based multimedia system for the administration and management of individualized technical training on a large scale. The primary function of the AIS is to provide training and management for up to 2,100 students per day in four selected courses currently being taught at the Lowry Technical Training Center in Denver, Colorado. A secondary function of AIS is to serve as an R&D facility for the Air Force to evaluate the cost and training effectiveness of instructional innovations. The AIS is being developed through contract with McDonnell Douglas Corporation (MDC). The contract is for approximately 10 million dollars, incrementally funded over a four-year period (Rockway & Yasutake, 1974).

AIS Courses

The four courses chosen for initial implementation are shown below together with a projected mix of instructional media.

Inventory Management (7 weeks)/**Materials Facilities** (6 weeks)	*IM/MF Projected Media Mix*	
	Printed	65%
– Supply-oriented/Warehouse operations	A/V	22%
– Low–Medium aptitude	CAI	13%
Precision Measuring Equipment (30 weeks)	*PME Projected Media Mix*	
	Printed	52%
– Calibration of test equipment, troubleshooting	A/V	26%
– High aptitude	CAI	22%
Weapons Mechanic (14 weeks)	*WM Projected Media Mix*	
	Printed	54%
– Flight line–team-oriented training	A/V	36%
– Medium aptitude	CAI	10%

The first iteration of materials is being developed in a single-track, media overlap, self-paced mode. Multiple tracks will be developed during the second iteration. At least a 25 percent savings in training time must be demonstrated with equal or better performance.

Adaptive Models (AMs)

The AMs within the system are currently under development and will provide the mechanism which, when based on student characteristics and available instructional strategies and resources, attempts to optimize the efficiency of training.

CMI Capabilities

The introduction of CMI capabilities in the AIS program will be iterative as the instructional materials and strategies and computer support become available, according to the following schedule:

INITIAL (January/75)
Test Scoring
Student Data Files
Data Collection and Analysis
Limited Reports
Student Enrollment
Real-Time Interaction at "B" Terminal

INTERIM (June/75)
Initial plus:
First Iteration AM
- Resource Allocation
- Module Assignment
- Student Prescription
- Remedial Assignments

Extended Reports
Real-Time Interaction at "A" and "B" Terminals

LONG TERM (January/76)
Interim plus:
Refinement of AM
- Adaptive Testing
- Incentive Management
- Student Prescription
- Course Completion Prediction
- Remedial Assignments

Full Reports
Task Inventory
Course Conversion
Field Follow-Up Evaluation

Computer Hardware

The following information summarizes the planned hardware configuration for the AIS program:

- Central Site Computer: CYBER 73-14
- Type A Terminals (≅ 105): Interactive graphic terminals for use in CAI and CMI functions (modified PLATO IV terminals)
- Type B Terminals (≅ 16): Management terminals consisting of OMR 6500 (5 lines per second); DI 240 – line printer (180 lines per minute); PDP-11/05 controller

Computer Software

The software elements of the AIS program are as follows:

- CAMIL (Computer-Assisted/Managed Instructional Language): A high level language to provide CMI/CAI capabilities for the AIS
- Operating System: Modified SCOPE 3.4.2
- Information Management System
- Applications Programs

Program Status

Approximately five weeks of instruction are implemented in a single track self-paced mode in the IM/MF course. Approximately six weeks of self-paced materials are in tryout stage in each of the other two courses. Initial CMI will be implemented in the IM/MF course in January of 1975. The first iteration of the Adaptive Model will be ready in June 1976.

Reference

Rockway, M.R. & Yasutake, J.Y. The evolution of the Air Force advanced instructional system. *Journal of Educational Technology Systems*, 2 (3), Winter, 1974.

PART III

CONFERENCE EVALUATION

CONFERENCE EVALUATION

Hurriedly marked responses to five preplanned evaluative questions at the close of a two-day conference is probably not the most sophisticated way to collect appraisal information. It does, however, have the advantage of being both an inexpensive and immediate source of data.

In Figure 3 we have shown the responses of 37 Conference participants to each of five simple questions regarding their reactions to the two-day conference. We can only presume that eight non-responding participants had to catch an early flight and could not contribute to the evaluation. We hope their sensibilities were not so greatly offended as to induce an early departure. The one-page questionnaires were intended to be anonymous, but four participants insisted on signing their names.

Clearly, the participants were enthusiastic about the value of the Conference to themselves, with 49 percent checking the "very worthwhile" option. No one thought it was "useless." Although it would be a mistake to attribute attitudes toward the future of CMI to this Conference, it is interesting that almost all of the participants thought that the applications of CMI during the next ten years would be "expanding."

This Conference had two major goals: 1) exchange of ideas and concepts about computer-managed instruction among program developers, and 2) formulation of policy recommendations which would enhance the orderly development of CMI. Question No. 3 deals with the first objective and shows that 23 of the 37 respondents felt that there had been a "great exchange" of information or something close to it during the two-day meeting. We believe the first goal was achieved satisfactorily. To achieve the second goal, participants were asked during the last late morning session to disperse themselves into seven groups of six persons each. The task set before each of the seven groups was to consider ten policy questions in the light of what had been learned about CMI at the Conference, and to formulate several important policy propositions concerning the applications of CMI in education and training. Upon completion of the task in the small group sessions, the total Conference reassembled to receive and discuss the policy recommendations. Although the groups of 44 Conference participants had been eating and working together for almost two days, it was clear that an insufficient amount of time had been allowed for the policy discussions. There was not enough time to develop a consensus among the group about the appropriate level of specificity for a statement of policy. The recorded discussion on CMI policy matters was not very fruitful. However, each participant was polled by mail within a week following the Conference and asked to give his or her reactions and recommendations on CMI development policy. A total of 23 participants responded to this invitation with a total of 104 separate identifiable comments. In the section which follows, the editor has attempted to sift and merge the policy ideas presented by the participants. Quotes are included from time to time which seem particularly cogent.

Question	Response	Mean Rating
1. On the following scale, please evaluate the usefulness of this conference to you:	(0)1 (1)2 (6)3 (12)4 (18)5 — useless … very worthwhile	4.27
2. Please judge the amount of new information disseminated at this conference:	(0)1 (3)2 (3)3 (19)4 (12)5 — very little … large amount	4.08
3. Please evaluate the exchange of ideas and concepts among participants at this conference:	(0)1 (4)2 (10)3 (13)4 (10)5 — little exchange … great exchange	3.78
4. After attending this conference, how do you view the applications of CMI during the next ten years:	(0)1 (0)2 (5)3 (15)4 (17)5 — decreasing … expanding	4.32
5. Please indicate your feelings of the appropriateness of the expenditure of federal funds for small conferences of this type involving highly knowledgeable participants:	(0)1 (0)2 (0)3 (11)4 (26)5 — inappropriate … very appropriate	4.70

Figure 3. RESPONSE FREQUENCIES FOR FIVE FIVE-CHOICE CONFERENCE EVALUATION QUESTIONS
N = 37

On CMI Conferences

Five participants commented favorably about conferences as a method of disseminating information about CMI:

"I believe a separate conference devoted to CMI should be held approximately every two years to convey ideas and information among the people interested in CMI. Jerry Lippey has done this with regard to computer-assisted test construction and the conference grew from 30 people in 1972 to 300 in 1974. I believe these conferences serve a very useful function. However, they tend to get too big eventually and one loses track of much of the detail. Therefore, the larger conferences need to get split by topic among developers, users, implementers and so forth. My own suggestion would be to keep the first two or three of these conferences limited to about 40 people and encourage interaction much in the way this last Conference was held."

"Sponsor periodical conferences such as that held in Chicago, November 6-8, 1974. There appears to be a sufficient number of conferences or symposia (through such organizations as the AERA and the APA) to discuss the more theoretical issues involved in CMI and CAI. Thus far, however, there seems to be much less emphasis on an exchange of ideas between those involved in the implementation of CMI in ongoing education and training."

"Almost the first thing that needs to be done is a massive campaign to educate educators in the meaning and potential of CMI. This can be done through a series of possibly government-sponsored workshops at professional societies, survey and tutorial articles in magazines which are read by educators, and introduction of computer courses into education curricula to make CMI a well known and understood subject."

"We also think that conferences such as the one you chaired should be continuous. A modification for future conferences might be that author's content should be a definite part of such conferences. Without the content the systems remain useless and there are many problems encountered both in the system and in content development which need to be shared and encountered by both. Time for more interaction is also needed in order to fully benefit from others' input."

"An expanded conference and/or special sessions of professional meetings (i.e., ADCIS or EDUCOM) should be convened to present carefully reviewed presentations and/or papers on CMI. Hopefully, out of this conference would evolve continuing special interest groups (formal or informal) involved with CMI. Clearly, one of the immediate problems in maximizing the contribution of CMI is to make individuals aware of the existing CMI, to prevent the reinvention of the wheel and to facilitate extrapolation of existing systems to new environments and new applications."

On Increasing the Acceptability of CMI

Nine participants made cogent statements related to ways that would, in their opinion, increase the acceptability of CMI applications in institutions concerned with education and training.

". . .the state of the art in CMI is such that it is ready for much wider application than is now the case. It also seems clear that it is in the interest of federal, state, and local governments, as well as in the interest of industry, to extend the applications of CMI."

"CMI should begin concentrating on the growing population of vocational and continuing education adult students. Two of the more outstanding presentations at the Conference told of work with these types of students. CMI was able to overcome travel and self-pacing problems in an impressive manner. The public schools, on the other hand, have an overabundance of teachers, few travel problems, and dwindling numbers of students which will probably create a hostile environment for innovative CMI technology."

"Efforts should be made through whatever means possible to establish experimental test situations for implementation of a CMI system in an environment other than that for which it was developed. This testing or extrapolation of CMI systems should provide valuable distribution and sharing experience as well as provide good research data on the benefits and application of the CMI system as transplanted. This idea is still somewhat vague in my mind, but holds potential particularly in these days of where declining budgets dictate the need for careful analysis of existing systems before the development of new ones."

"The following actions can be taken by universities to promote the development of CMI systems: a) offering courses related to CMI, b) incorporating basic computer knowledge courses in teacher training programs, c) encouraging instructors of courses to employ the CMI approach, and d) modifying regulations which may handicap instructors' participation in developmental activities and students' enrollment in courses managed by computers."

". . .there was a great deal more variability in the extent to which various CMI systems have been accepted by and successful in their respective institutions than can be accounted for simply by the quality of the systems themselves. For lack of a better word, political considerations appear to be a much greater factor in determining acceptance than does system sophistication. It may well be that the field would benefit from an intensive study of those factors which inhibit or facilitate CMI success in different settings."

"Limited research must be continued with projects that meet specified criteria in selected areas of educational technology. Enough money must be allocated to insure success or failure. Three-year funding or less is not going to yield answers."

"My recommendations involve action at the federal level that needs to be taken if the contributions of CMI are to be maximized in the next decade. This does not, of course, preclude the involvement of agencies and organizations at the state and local level but does support the concept that the higher the level of action the greater the national impact."

"It seems to me that CMI as we know it today is perfectly [sic] technically feasible on a variety of equipment, both large and small; therefore, the most pressing issues in CMI are not technical ones, but rather issues of acceptance and utilization by large numbers of people."

"Provide funding support for the development of CMI systems. Guidelines should be established to delineate the characteristics of CMI systems that should be incorporated into the development projects. Proposals should be elicited that place an emphasis on development of CMI systems that: a) effectively support the instructional process, b) efficiently and reliably perform the tasks they are designed to do, c) support a wide range of subjects and instructional modes, d) are not hardware or software dependent, and e) are transparent to the user."

On the Need for Model Demonstrations of CMI Systems

Six comments by the Conference participants emphasized the efficacy of models and demonstration sites for advancing CMI applications:

"I think it is important that a CMI demonstration site be established. The site must have a service function for a variety of student populations. It also must have a development and research function for courseware, software and hardware dimensions of CMI. The site might possibly work in conjunction with a CAI installation."

"Several demonstration projects in CMI should be funded. These should *not* include development of new hardware and should *not* be on a grand scale. Such systems should be field tested in a variety of

locations, and the experiences and costs of required elements, such as training of teachers and suitability of equipment, should be documented."

"A demonstration school with opportunities for experienced and student teachers to teach in these situations would provide a core of experts who could return to their own school districts to design and implement local demonstrations."

"Major demonstrations should be conducted in an engineering manner. The field setting is the real developmental laboratory. While some research needs to be maintained, at least two major developmental-demonstrations should be mounted in educational technology, with the design to include increasing productivity in education. CMI needs a major demonstration effort as CAI has had."

"Problems-oriented research must be conducted on specific needs that come from demonstrations. It should not be the role of the demonstrator to solve research problems. However, it is a suitable role for the demonstrator to identify specific problem areas that need research answers."

"There are some CMI projects already in existence which could be smoothed into model projects, or new model CMI projects could be conceived, funded, and made available for demonstration. This should cover the spectrum of application as to grade level, economic level, and type of educational institution, and should be broadly based relative to hardware and software. That is to say a variety of manufactures in sizes of main frames and styles of operating systems should be used."

On Establishing a CMI Information Clearing House

About one-quarter of the participants recommend establishment of a CMI clearing house that would facilitate the exchange of information and program materials. Some representative comments follow:

"Establish a clearing house which provides catalog-type listings and descriptions of subject matter which has been self-paced or individualized in a manner amenable to CMI. It still appears that those involved in implementing CMI projects spend a significant amount of effort in developing instructional materials. If materials which have already been developed could be exchanged, it would allow those interested in CMI *per se* to expand their efforts on more CMI-related issues rather than in developing teaching materials."

"Establish a clearing house for dissemination of information on various CMI projects (i.e., public schools, universities, military and industry). There are many very worthwhile projects going on throughout the country which are not well publicized. It would be very beneficial to have some mechanism for exchanging information with those involved in various kinds of CMI projects."

"Funds should be made available to set up a communications network where all items funded by government remain in the public domain and can be accessed by interested parties. Transfer funds for initial start-up should be available."

"To summarize, I believe the biggest problem facing CMI at the current point in time is that of communication among the various interested people so we can get some idea of the structure and scope of the field and at the same time try to pull out the various theoretical frameworks that sit underneath these endeavors. Most of the people at the Conference were essentially implementers rather than theorizers. However, at some point in time we need to have enough information to sit back and ask the question–what are we really doing in CMI? Such an open communication network would greatly facilitate this effort."

"There should be some formalized mechanism for collecting and exchanging information about CMI installations. The forms described above could be collected by some central agency such as Penn State or NIE or somebody else and distributed yearly as a package or individually upon request especially to

those people having submitted forms–they should automatically get the complete set. These formal mechanisms take very little effort and yet can serve a very good function within the field. It means a little bit of clerical labor for some people, but I think there are those willing to do that in exchange for a certain amount of glory."

"Set up a clearing house (at the federal level) for machine readable test item banks to minimize duplication of efforts in developing item banks."

"Some means must be found (I hate to suggest another central clearing house) to disseminate information relating to well conceived, reliable, operating, available, economical, transportable, etc., CMI programs."

"A clearing house for the collection and dissemination of information and materials concerned with CMI should be established. This could be similar to the organization established by the National Library of Medicine to take care of audio-visual materials. It was demonstrated at this CMI Conference that there is much being done in CMI around the country, but not much sharing going on."

On Clearing Up the Definition of CMI

Several of the participants commented vigorously on the need for nomenclatures and descriptive conventions for use in connection with CMI operations. In their comments, none of the participants referred to the pre-Conference documents (p. 1) which proposed three distinct levels of sophistication in CMI systems. Either they had not read the advance material or they did not consider the attempted classification scheme to be relevant. The most interesting comments on this topic are as follows:

"Much of the CMI work reported at the Conference in Chicago was very closely akin to CAI. I think it is important that we recognize that CMI arches the entire range from individualized testing and prescription to the management of the instructional system of a complete institution."

"Initiate an effort to define and categorize different levels of CMI (e.g., on-line vs. batch processing). There is still a lack of standardized definitions of CMI. Some systems appear to be quite sophisticated in their CMI approaches (e.g., on-line testing and student prescriptions). Others appear to depend on overnight batch processing of student progress data. Both categories are called CMI. There needs to be a clearer definition and categorization of these functions and levels of CMI so that everyone is talking about the same thing."

"Clear specifications should be made by educators of what a CMI system is. The purpose of these specifications is not intended to limit individual developments. It is intended to provide helpful guidelines for those interested in developing a CMI system. The specifications should provide the following information: a) the roles of instructors, computer, instructional and testing material in a CMI system, b) how instructional and testing material should be developed to fit into a CMI system, and c) the software and hardware required to implement such a system."

"I believe suggestions and recommendations proved difficult because we lacked a clear definition or definitions of CMI. The presentations described projects from a limited retrieval system to rather sophisticated CAI projects. So first, I would suggest clear definitive guidelines be established so we are not comparing apples to oranges. This probably means we need more categories than CMI and CAI. Perhaps we could define by functions, rather than such broad general terms!"

"Develop a taxonomy to classify and compare CMI systems which emphasizes the decisions for which data are provided and which minimizes the report format for hardware and software characteristics."

"Develop a suggested nomenclature for CMI concepts which includes concepts in the instructional, software, and management domains."

"Sponsor studies to define the role of teachers, instructors and aides within a CMI environment. Much of the current emphasis in CMI is focused on management of students without a real look at the role of the instructor in this new environment. This is a very critical area. There needs to be a much more thorough and systematic effort to define the role of teachers and training managers and to come up with suggestions regarding such areas as selection and training of such people."

"Arrange for an impact study with analysis of impact on jobs, nature of work situation, changes for teachers, changes in relationships to the educational process on the part of the students, related family, public leaders, etc."

"There should be developed a standard form for describing CMI systems using a consistent set of characteristics that deal with the curriculum plan, the instructional model, the management philosophy, and the use of the computer as a major set of headings. We could make a pass through the known systems from the Conference with such a form and use them as the debug tool to develop a good one. Subsequently, we could mail these out to the people responding to the inquiries mentioned above and have them filled out and collected at a central point for dissemination. Perhaps they could even be inserted into ERIC or something along these lines. I think such a data collection mechanism would be extremely helpful for fields which are as fluid as CMI is. Periodic follow-ups could also be conducted to find out how many systems have died over a given period of time."

On the Importance of Theory in CMI

Many of the participants in their comments referred to the need for a theoretical undergirding of CMI systems. Four of the most explicit comments are as follows:

"Development is needed of instructional theories that can be employed by CMI systems. Theories of instruction deal with the organization of instructional and testing options in order to optimize the effectiveness of the learning process. Such theories are indispensable for developing an effective CMI system and also for evaluating such a system."

"Basic research must be expanded in learning theory, teaching theory, biochemical studies, and the sociology and anthropology of education."

". . .our efforts seem to be uniformly inadequate with respect to instructional technology. I have always been concerned that if and when the technical problems of CAI were resolved, we would still be unable to use the capability effectively. I think we may very well have reached that stage with respect to CMI. That is, we may be approaching asymptote with respect to knowing how to build an adequate management system, but we are still grossly inadequate in knowing how to use that system effectively. The crux of the problem, as far as I am concerned, lies in our limited ability to detect relevant individual differences and to tailor instruction to those differences. While CMI can provide the management tool, it cannot provide the management rationale."

"CMI does imply a change in the teaching and learning process in the classroom. *Individualized instruction* were key words throughout the Conference. However, our ability to change human behavior lags behind our technical capabilities. Much needs to be done with the training of people to accept and use the technology available now. I dare say most teachers—elementary, secondary, and university—are presently opposed to CAI and/or CMI projects."

On Making CMI Cost-Effective in Education

The participants generally seemed to believe that a portion of the promise in CMI applications lay in the criterion of cost effectiveness. Three comments were representative:

"In times of tight money, which it looks like we may be in for some time to come, emphasis should be placed on ways to do an equal job for less money. If computers are to be used to assist in cost reductions, then it would appear that CMI might show the way. My personal *opinion* is that we will find that the cheapest way to provide CMI, which in turn will help reduce overall educational costs, is through the use of mini-computers."

"Direct attention should be given to efficient low-cost data transmission hardware. Hopefully, CMI (whatever it is) can avoid the prohibitive cost of terminals and direct line hookups to computers."

"Sponsor research to define and develop a family of low- to medium-cost computer terminals in support of CMI. Much of the current research efforts appear to be aimed toward the use of such terminals as those represented by the PLATO IV project. Depending on the sophistication of CMI, much less expensive terminals would probably do the job. There needs to be research to define the functions of CMI and then to develop computer terminals to support these specific functions."

Summary

The participants in this Conference are generally optimistic about the potential of CMI for impacting education and training. They were impressed with the wide variety of developed CMI systems discussed at the Conference. There was a general endorsement of the need for increased funding for research and development in CMI and for greater dissemination efforts, including frequent conferences. The participants make a persuasive case for the establishment of information and course material clearing houses. They believe that setting up model CMI systems would increase the acceptability of computer-based education as a viable alternative to traditional programs of instruction.

APPENDIX

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Computer Technology: Its Future Role in Basic Education

"The gap between computer-based potential and current practice in schools is gigantic. . . . a staggering total annual opportunity of 22½ billion instruction hours exists."

The purpose of this paper is to briefly review major applications of computer technology in schools and to examine the constraints and incentives which will bear on their future role in basic education. I will restrict my remarks to computer applications in public and private lower schools.

Major Uses of Computers in Schools

There is no completely satisfactory way to classify known computer applications in schools because of the wide diversity of practice. There are, however, four major applications: (a) computer as an administrative aid; (b) computer as a scientific, arithmetic problem solver; (c) computer as an information retriever; and (d) computer as an instruction facilitator.

Administrative Uses

Computers have their largest education application in administrative functions: preparation of payrolls, accounts receivable, accounts payable, and inventories. Teacher organizations favor the administrative use of the computer as a dues checkoff device.

Scientific Computing

The rapid growth of research and development activities in colleges and universities has been made possible by a parallel growth in computer technology. Scientific computing in higher education, as differentiated from instruction to students in computing techniques, has been the principal education application of computers.

Problem solving with computers, though less frequently applied in secondary schools than in colleges, is becoming increasingly important. Korotkin et al., in a survey for the National Science Foundation (NSF), learned that about 13 percent of U.S. secondary schools had some type of computer either on school grounds or available to staff and selected students through a remote terminal (1).

Information Retrieval

Not so well advanced is the use of the computer as an instantaneous retrieval device. This application for separating one from many depends upon disk storage and time-sharing equipment which are commonplace in universities and large industries, but rare in schools. For the future, computer-based information retrieval looks promising as schools try to improve their services. The Remote Access Management System (RAMS), conceived and operated by the Oakland Intermediate Schools in Michigan, illustrates such an application.

Instruction Facilitation

The fourth major application of computers is in facilitating instruction. Three subdivisions of this use are discussed below: *drill-and-practice; computer-managed instruction* (CMI); and tutorial or *computer-assisted instruction* (CAI). The gap between computer-based potential and current practice in schools is gigantic. If there are approximately 50 million children in grades K-12 who spend an average of 5 hours per day in school, then there are 250 million hours of scholastic effort per school day, of which perhaps half is adaptable and appropriate to either complete pupil/computer interaction, or to some kind of computer supplement to regular lessons. With 125,000,000 hours available per day during a typical school year of 180 days for some kind of computer-based interaction, a staggering total annual opportunity of 22½ billion instruction hours exists.

This opportunity can be met in a variety of ways. *Drill-and-practice* applications are perhaps the best known. Typically, the subject is mathematics or some other well-ordered material where each learner gets a 10-15 minute "shot" per day at carefully programmed material. Initial exposure of the pupil to the particular concepts has been accomplished by traditional means. In this sense drill-and-practice on the computer is supplemental to mainline instruction.

In using a *computer-managed instruction* (CMI) system the learner also acquires information, skill and concepts in traditional ways. The computer is used for testing, recording, and synthesizing a performance record for each learner. In primitive CMI systems the computer-generated information is used by a teacher to make individual

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diagnoses and prescriptions for learners. In advanced systems, the learner uses the computer and receives his or her own diagnostic and prescriptive information. Fewer than a dozen CMI systems in active use involve a few thousand students annually. However, because CMI systems are relatively inexpensive, their development seems assured.

When most educators speak of *computer-assisted instruction* (CAI), they envision a tutorial application involving both the learner and the stored program in the computer. The Socratic model of one teacher and one learner has generally been followed. A time-sharing feature on many computers makes it possible for each of several learners to feel that he or she has the exclusive attention of the device. The curriculum is offered in such a way that the student is expected to reach the objectives of instruction at the computer terminal without outside study. Thus, in tutorial CAI the computer can be thought of as being *integral* to instruction, whereas in CMI and drill-and-practice modes the computer activity is supplemental.*

Although computer technology has had considerable influence on American life, it has not yet had much impact on major instruction programs in schools. If the computer is to realize its potential in schooling, what are the conditions under which computer technology is the key to the future?

Rationale

Many protechnology enthusiasts [Tickton (2), Carnegie Commission (3), Committee for Economic Development (4), and Worth (5)] have assumed that the potential power of computers would be brought to bear on education. They have justified this position by assuming that because the computer has become indispensable to science, research, business, industry, banking, travel and dating bureaus, it will soon become an indispensable tool of instruction. This position fails to account for constraints as well as incentives for bringing computer technology to bear on the mainstream of schooling in this country.

Although we have by no means considered all factors, the subsequent discussion is organized around the following topics: (a) expectations of schooling, (b) demand for diversity, (c) toward more humane schools, (d) creation of an education market for computers, (e) staffing the computer-based curriculum, and (f) paying the piper.

* The author has intentionally omitted the instructional applications in computer science and data processing courses in which the computer is employed as a tool to teach computer programming.

Expectations of Schooling

Many citizens are dissatisfied with current results of schooling [Silberman (6)]. Employers can't trust a high school diploma to be a literacy credential. Ghetto parents know that their children don't like school and are not acquiring basic skills. College professors are appalled by the absence of scholastic skills on the part of new students. But despite these recurring and valid complaints about the results of schooling, our society still honors knowledge and employable skills, and the average citizen is aware that with a little tightening up here and there, particularly on the part of teachers, the schools can turn out a satisfactory product. To suggest a massive infusion of new computer technology into a pervasive climate of so-so satisfaction with schools is to court failure and frustration. We as educators and molders of public opinion must raise citizen expectations of their schools. Our children are capable of learning, achieving, and creating much more than our schools and homes are currently affording. Sizer offers an extensive discussion of this point (7). The logic and preprogrammed decision-making capabilities of the modern digital computer make it the only candidate immediately in view that can handle the complex task of monitoring, summarizing, diagnosing and prescribing instructional moves simultaneously for many learners. Of course, educators do not yet know which of the hundreds of descriptive variables about learners are most relevant for instruction. But this needed evidence represents an empirical question which can be derived from the experience of programming courses of instruction for computer presentation and trying them out on learners with many hypotheses about different learner-adaptive variables.

"We as educators and molders of public opinion must raise citizen expectations of their schools. Our children are capable of learning, achieving, and creating much more than our schools and homes are currently affording."

We have long recognized the motivating effects of self-direction or independent study. If instruction can be put into computer storage, and learners given a wide variety of choices in deciding what they want to learn and in what sequence, then education will be blessed with increased motivation and improved learner self-direction. These computer applications depend neither on new technological developments nor on new pedagogical concepts. The major restraints lie within the social institutions responsible for education.

Demand for Diversity

Toffler makes a persuasive case for the long-term trend of increasing diversity in life styles and consumer products (8). In his view, the use of computers in schools offers the opportunity to respond to increased citizen demand for diversity.

However, this demand for diversity is not being responded to adequately by most educators

in daily contact with children. The conflict thereby created will not be alleviated by adding more policemen to the school staff, nor by reducing average class size from 30 to 28 students. On the other hand, computer programs which encourage inquiry, simulate real world processes, and provide for widely varying pupil interests do create a diverse environment for learning.

The computer makes it possible for educators to greatly expand the available curriculum for learners. The knowledge retrieval capability of large computer systems, plus the storage and use of adaptive information about learners will make it possible for every learner to have a unique curriculum. No longer will debates about curriculum be restricted to what can comfortably be taught to an average group of students at a particular grade level. The computer makes it possible for learners to have individual access to a wide variety of knowledge. Instead of long debates about what is worth teaching, future educators will be able to shift this responsibility to the learner.

"If instruction can be put into computer storage, and learners given a wide variety of choices in deciding what they want to learn and in what sequence, then education will be blessed with increased motivation and improved learner self-direction."

Most people who remain ignorant of the essential open-endedness of a computer system believe that it is a device which impersonalizes and dehumanizes people. But in actuality the computer is capable of responding, *when programmed properly*, to an almost infinite variety of patterns of behavior, physical characteristics, and tastes. Children who have not been taught to fear technology quickly grasp the diversity inherent in the computer and often become its devotees.

Toward More Humane Schools

One root cause behind the common observation that schools fail to educate lies in badly deteriorated relationships between teachers and students. The crisis in teacher-student relationships is seen in school statistics on excessive absenteeism, vandalism, drug abuse, riots, and violent attacks on authority figures. School is perceived by students as a spiritually destructive place which fills no essential need in their lives. Teachers and administrators are viewed as adults who "holler" at kids, enforce petty rules, and wield arbitrary power. An adversary system dominates classroom interaction where the teacher, backed up by the principal and guidance counselor, is pitted against the students. While destructive interpersonal games are played out in some schools, society uneasily watches from the sidelines.

One of the first things we must do to reform schools is to increase the expression of human warmth between adults and students. The challenge is how to change the emotional climate of the classroom without sacrificing progress in the achievement of academic goals. Students must be rewarded for their honest attempts to learn. To provide them with praise and other positive indications of their self-worth, we must obtain more feedback than is characteristic of the classroom which provides a cage for 25-30 children, one teacher, and a variety of inert materials. Medley and Mitzel have shown that most lessons above primary level are conducted either as an expository lecture or a class discussion (9). Individual students have only minimal opportunities to interact directly with the teacher, who must somehow instruct 30 students as if there were only one.

In a previous article I have shown how an aggressive, able youngster in a traditional class discussion can recite and receive feedback, including praise, 4 or 5 times during a 40-minute class period (10). A shy, withdrawn child is easily overlooked and unnoticed and may recite with expressions of teacher approval only once a week. Contrast that mass-education picture with the computer-assisted instruction workroom where every child receives feedback and encouragement of his or her learning efforts once every 30 seconds, on the average, for a total of 80 different rewarding and informative exchanges in a 40-minute period at the computer terminal.

With sensitive programming, computer terminals can create an absorbing, responsive environment for learning. The student knows that when he or she makes a response, something will happen immediately to provide him or her with an appraisal of the quality of the response and offer guidance toward future efforts. There is little wonder that 450 ninth graders in a Pittsburgh high school who spent a portion of their daily mathematics lesson at the computer terminal and a portion in individualized study with print media markedly preferred the computer experience (11).

So far we have discussed the superiority of the computer terminal over conventional mass instruction in creating a responsive environment associated with typical learning activities. But there is an additional opportunity for greatly improving the quality of the school climate when computer tutorials are introduced into schools.

To understand this second opportunity we can classify classroom teacher skills as being of a higher or lower order. Examples of lower order skills are: presentation of information to be learned, display of drill and practice exercises, evaluation of student responses, and provision of feedback. Examples of higher order skills are: diagnosis of a student's learning disability, mediating a dispute, assessing the impact of a student's home environment on behavior, and expressing comfort for a wounded spirit or an injured body. The cause of instructional reform would be greatly advanced if lower order skills were handled by carefully sequenced computer programs. Teachers

would spend less time on lower order skills and would transfer their uniquely human talents to the higher order skills for which there is no computer programming in the foreseeable future. Many teachers would have to be retrained in order to shift their emphasis from lower order skills to higher order ones.*

Silberman documents the great interest being expressed by American educators in the British infant school model (12). By minimizing structure and emphasizing student freedom to inquire and explore, those schools are unquestionably improving schoolgoing attitudes on the part of students. Many Americans will, however, be unable to accept the absence of the traditional lesson plan with its interest-arousal activities, presentation, exhortation, and follow-up by the teacher, all of which "turn off" most children in today's schools.

Since the close of World War II, Americans have been trying to improve their schools by increasing the subject matter knowledge of classroom teachers. Federally sponsored institutes since the passage of the National Defense Education Act (NDEA) of 1958 have made it possible for many teachers to increase their knowledge. The rationale for this new interest in inservice teacher education was the notion that a teacher cannot teach well those subjects which he or she does not know well.

It seems to me that the heavy emphasis on student acquisition of hard content, characteristic of the postsputnik era, has been bought at the price of a declining interest and concern among educators for the human values which should be a part of schooling. If we shifted a major portion of the lower order presentation skills to a rich CAI environment and then retrained our teachers to engage in and emphasize higher order human relations skills in the classroom, we could reform the education of many Americans. Paradoxically, computers, the epitome of impersonality and product of the space age, offer us an opportunity to reform our schools by making it possible to redirect efforts and humanize schooling.

Creation of an Education Market for Computers

One reason for the slow assimilation of computer technology into the instructional heart of education is the unavailability of hardware and operating systems specifically designed for instruction. Computer manufacturers have been unable to recognize an unambiguous mass market for education machines. Instead, the pattern has been to encourage CAI developers to try to adapt business-oriented equipment to the pedagogical needs of subject matter. It's not working! Bank teller computer terminals and teletypes are obvious misfits in the world of pedagogy. Some developers have been willing to make compromises with the real world in order to try to use such equipment for teaching purposes. Others have opted for the lean or business terminal on the grounds of economy.

An attempt to adapt computers to CAI needs was made by the International Business Machines (IBM) Corporation in 1967. At that time IBM developed a special limited version of an instructional system, the IBM 1500. Only 25 units were assembled and marketed. The majority of these are still operating in university research and development laboratories. More recently, under sponsorship from the National Science Foundation, the PLATO project at the University of Illinois (13) and the TICCET project at the Mitre Corporation (14) are attempting to fill the void in computer terminals designed for instruction as part of complete new systems.*

It is, however, unfair to place all of the blame for turtle-paced progress in CAI application on the hardware community. Schools must recognize that there is a long-term developmental process involved in applying computer technology to instruction. Schools can create the beginnings of a mass market for manufacturers by investing in some early design equipment. It should be understood that pioneering equipment has to be tried out in the field so that redesign and improvement can occur. The schools should also be aware that the existence of a mass market ultimately brings down the cost of technological products.

Of all the constraints operating to prevent optimum application of computers in schools, none seems more dismal than the "waiting game." Manufacturers are waiting for a mass market to appear for CAI equipment. Schools are timidly waiting for 21st century sophistication to appear in CAI systems before investing a nickel. Curriculum developers, instructional technologists, the federal government, and others in the middle are waiting for both sides to move. We believe that a break in this crisis of leadership will come with federal initiatives toward long-range planning. The same type of effort now being applied to the energy crunch would also well serve the needs of computer applications in schools. Our planning should target the dates for achievement of specific inter-

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*We are not necessarily recommending the use of the computer in this massive retraining effort, but it should be noted that CAI has been used effectively for inservice teacher education at Penn State since 1971.

* PLATO is an acronym for Programmed Logic for Automatic Teaching Operations. TICCET is an acronym for Time-Shared Interactive Computer-Controlled Educational Television.

mediate goals with realistic schedules for research and development activities.

Staffing the Computer-Based Curriculum

Sizer sets the tone for a discussion of constraints on CAI provided by working educators in the schools:

> The possibility that computers will be used in schools seems to turn otherwise reasonable men and women into either implacable Luddites or idealistic zealots. To some the machine is the symbol of inhumanity, a blinking rigid monster devoted to the dehumanization of the school. To others the computer is the route to new pedagogical sophistications, a device to free the child from the clutches of the biased, smothering teacher. Luddites think of zealots as bloodless technicians. The latter find the former fearful reactionaries. Both Luddites and zealots are wrong, of course, and both are perversely right . . . a new group of educators, who are neither Luddites nor zealots, needs to be formed, and serious inquiry on the purposes of computer technology in reaching them must be pressed (15).

"A militant stance by teacher organizations on the job preservation issue as the price for admitting new technology would not bode well for the future of the schools."

Although the widespread use of computers in schools might not change the overall staffing needs in the knowledge industry, there would undoubtedly be major shifts in the pattern of jobs and in the training required for their execution. CAI in schools would likely create a differentiated staffing pattern where there would be fewer workers in the middle salary bracket of $10,000-15,000 annually. Presumably, there would be more appointments of paraprofessionals (at $6,000-7,500) and high-level specialists (at $20,000-25,000). Assuming a reform of education based on the benefits of the new technology, there would be a marked decrease in the necessity for specialists such as remedial reading teachers, guidance counselors, special education teachers, and resource room teachers. On the other hand, the number of curriculum designers, instructional technologists, and audio-visual illustrators should markedly increase.

The goal for the zealots to which Sizer refers above is to be able to convince the politically sensitive leaders of teacher organizations that the long-term interests of their members are better served by qualifying for better paying, higher level, more technically and managerially involved positions than is presently the case. A militant stance by teacher organizations on the job preservation issue as the price for admitting new technology would not bode well for the future of the schools. Society would undoubtedly begin to look elsewhere for new educative mechanisms.

Paying the Piper

A major constraint to sizeable computer application in instruction is the current budgeting practice. School systems characteristically allocate 80-90 percent of their operating budgets to personnel costs associated with instruction. After taking out costs such as debt reduction and physical plant maintenance, there are practically no degrees of freedom. Rising personnel costs must be met with an increase in the total operating budget. Most laymen can only conceive of the purchase of instructional equipment as an item in the operating budget. Obviously, the purchase of a million-dollar computer for a school organization with a $15,000,000 annual operating budget is 8.5 percent of the $12,000,000 already committed to teaching personnel on a continuous basis. Even if the same pupil services could be shown to be provided by the computer, the social and political pressure generated by a release of 10 percent of the teaching faculty would be fierce.

One way to make a nontrivial application of computer technology in schools is to think of a computer as a long-term capital investment in a teaching tool. In a sense school buildings are teaching tools and they are characteristically amortized over a period of 30-50 years.

No one has thought much about amortization of computers because they have characteristically had a high obsolescence rate as successive generations of faster and more powerful machines have been made available by manufacturers. Because third and fourth generation computers depend on miniaturized components, it is safe to conclude that the useful life of the devices has been greatly extended. With proper maintenance, it would not seem to be an undue risk to estimate that an instructional computer would serve a typical school for 15-20 years. Spreading acquisition and benefits over a relatively long term drastically reduces the impact of a computer application to instruction on the annual operating budget of a school. Such a plan helps to redress the imbalance of excessive labor intensity in school financing by increasing dependence on a capital investment.

Purchased computers applied to instructional tasks have another financial advantage. The long-term projection for personnel salaries is on a rapidly rising curve. The inflationary spiral is almost guaranteed to make wages for teachers a major bargaining point between school authorities and teacher organizations. This means that more dollars will have to come from tax sources to meet escalating demands. On the other hand, interest rates paid on bonded indebtedness for equipment acquisitions is steady. In the long run, a school can save money if its operations are somewhat less labor intensive and its budget less subject to increases due to inflation.

Other large cost items associated with the adoption of computers in instruction are con-

cerned with the development and maintenance of curriculum. Variability exists in costs of computer programs designed and tested for different uses in schools. For example, drill-and-practice programs in arithmetic can be produced inexpensively because the computer generates its own numerical values from a simple set of instructions. Frame-oriented tutorial programs, however, are costly because the author/programmer must anticipate a wide variety of learner responses and instruct the computer to make appropriate feedback. High quality tutorial material, based on our experience at Penn State University's CAI Laboratory, costs between $5,000-$10,000 per average learner clock hour. Thus, at midrange prices, a 30 clock-hour course costs approximately $225,000 to build. There does not seem to be enough accumulated experience to forecast the development costs for computer-based games, simulations, and extended inquiry.

Education is so decentralized that it seems unlikely that individual school organizations will be able to afford the development of their own computer-based curriculum. Statewide or regional consortia seem to be the best bet for actually putting programs together. Even if states or regions can mount the necessary curriculum initiative, it will probably be up to the federal government to provide the financial resources for massive program development. Solutions will have to be found to the problem of incompatible computer systems, and to the problem of how schools can inexpensively make minor changes in programmed materials.

References

1 Korotkin, A. L., C. A. Darby, and T. Romashko. *A Survey of Computing Activities in Secondary Schools*. Washington, D. C.: American Institute for Research, 1970. ED 047 500

2 Tickton, S. G., ed. *To Improve Learning: An Evaluation of Instructional Technology*. vol. 1. New York: R. R. Bowker, 1970.

3 Carnegie Commission on Higher Education. *The Fourth Revolution: Instructional Technology in Higher Education*. New York: McGraw-Hill, 1972.

4 Committee for Economic Development, Research and Policy Committee. *Innovation in Education: New Directions for the American School*. New York: Committee for Economic Development, 1968. ED 022 376

5 Worth, W. H. et al. *A Choice of Futures*. Edmonton: Alberta Commission on Educational Planning, 1972. ED 077 069

6 Silberman, H. *Crisis in the Classroom*. New York: Random House, 1970.

7 Sizer, T. R. *Places for Learning, Places for Joy*. Cambridge: Harvard University Press, 1973.

8 Toffler, A. *Future Shock*. New York: Random House, 1970.

9 Medley, D. M. and H. E. Mitzel. "Measuring Classroom Behavior by Systematic Observation." In *Handbook of Research on Teaching*, edited by N. L. Gage. Chicago: Rand McNally, 1963.

10 Mitzel, H. E. "Computers and Adaptive Education." *American Education* 6, no. 10 (1970): 23-26.

11 Hall, K. A. "The Development and Implementation of High School CAI Algebra and General Math." *Journal of Educational Technology Systems*, in press.

12 , Silberman, *Crisis in the Classroom*.

13 Bitzer, D. L. and D. Skaperdas. "The Design of an Economically Viable Large-Scale Computer-Based Education System." In *Computers in Instruction*, edited by R. E. Levien. Santa Monica: Rand Corporation, 1971.

14 Stetten, K. J. "The Technology of Small, Local Facilities for Instructional Use." In *Computers in Instruction*, edited by R. E. Levien. Santa Monica: Rand Corporation, 1971.

15 Ellis, A. *The Uses and Misuses of Computers in Education*. New York: McGraw-Hill, 1974, p. ix.

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Source: *Journal of Teacher Education*
Vol. XXV, No. 2, Summer, 1974, pp. 124-129